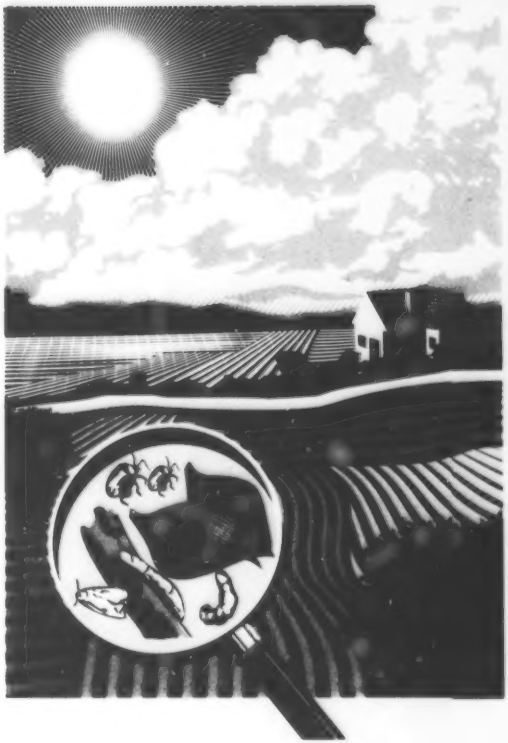
Field Scouting Guide



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Field Scouting Guide

First Steps in Integrated Pest Management

Insects, Diseases, Weeds

Table of Contents

Introduction		1
Insects:	True armyworm and fall armyworm	4
	Bertha armyworm	6
	Cabbage maggot	8
	Cereal aphid	10
	Colorado potato beetle	12
	Cutworm	14
	Diamondback moth	16
	European corn borer	18
	Flea beetle	20
	Grasshopper	22
	Hessian fly	24
	Lygus	26
	Painted lady butterfly	28
	Pea aphid	30
	Potato aphid	32
	Sunflower beetle	34
	Sunflower midge	36
	Sunflower seed weevil	38
	Wheat stem maggot	40
	Orange blossom wheat midge	42
	Wheat stem sawfly	44
	Wireworm	46
Diseases:		
Dry Beans	Bacterial blight	50
	Leaf rust	52
	White mould	54
Canola	Blackleg	56
	Black spot	58
	Sclerotinia	60
Cereals	Bacterial blight	62
	Barley yellow dwarf virus	64
	Common root rot	66
	Ergot	68
	Fusarium head blight	70
	Leaf rust	72
	Septoria leaf and glume blotch	74

	Stem rust	76
	Tan spot	78
	Wheat streak mosaic	80
Flax	Fusarium wilt	82
	Pasmo	84
Lentil	Anthracnose	86
	Ascochyta	88
Field Pea	Foot rot and mycosphaerella blight	90
	Powdery mildew	92
	Root rot	94
Potato	Early blight	96
	Late blight	98
Sunflower	Downy mildew	102
	Phoma	104
	Rust	106
	Sclerotina	108
	Verticillium Wilt	110
Weeds:	Barnyard grass	114
	Green foxtail	116
	Quackgrass	118
	Wild oats	120
	Canada thistle	122
	Cleavers	124
	Dandelion	126
	Hempnettle	128
	Lamb's quarters	130
	Perennial sow thistle	132
	Redroot pigweed	134
	Round leaf mallow	136
	Shepherd's purse	138
	Smartweed	140
	Stinkweed	142
	Stork's bill	144
	Wild buckwheat	146
	Wild mustard	148

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Weeds – Manitoba Agriculture, University of Manitoba

Introduction

The Field Scouting Guide is designed to assist growers and agronomists in making pest management decisions. These decisions must be based on accurate information which can only be obtained through effective field scouting. At the beginning of each section in this book there is a brief discussion of proper scouting techniques for insects, diseases and weeds. Where applicable, more specific scouting techniques are listed under each pest.

This book is a guide to the first steps in integrated pest management. Being able to identify and know the lifecycle of each pest are key to effectively managing pests. Integrated pest management is a comprehensive approach to managing pests (insects, diseases and weeds) using a variety of tools. In the end, integrated pest management will enable growers to lower the cost of production and increase farm net income.

Integrated pest management requires planning and the timely use of appropriate management strategies. Crop rotation is the single most effective way of keeping many of the pests affecting field crops at manageable levels. Knowing which pests impact your field crops will help you decide which management practices and crop rotations are best suited for your farm. Economic thresholds can help guide short and long term pests management programs.

Throughout this book there are many references to the *Guide to Crop Protection*. Every year a new *Guide to Crop Protection* is published which contains current information on economic thresholds, pesticide resistance updates and pesticide recommendations. The *Guide to Crop Protection* is available from your local agricultural representative office.

Scouting for Insect Pests

When scouting for insects in a crop, the aim is to identify any pests present, assess the potential of one or more species becoming a problem, and estimate the density of the pest population. Because different pests occur from seeding to harvest, weekly inspections are recommended.

Some pests, like grasshoppers, can be seen and their populations estimated by simply walking slowly through the field and making careful observations. Others, like seed maggots, root maggots, and cutworms, may require getting down on your knees and using small tools (e.g., trowel, pen knife, soil sieve, hand lens). Still others, like lygus bugs, may require the use of a sweep net or other collection device.

In other cases, you may be more interested in the percent of leaf defoliation, rather than in the number of individual insects present. The methods and tools used for specific pests are given in the following pages.

True Armyworm and Fall Armyworm

True armyworms do most of their feeding damage to cereals as nearly-mature larvae during July. Larvae feed on the leaves, stripping the leaf margins and move up the plants to feed on the panicles and flowers, stripping off the awns and kernels.

Fall armyworms may feed on dense, lodged cereal crops but are most common in corn. They may feed on the leaves and developing ears but prefer to feed on the succulent leaves in the whorl first. Feeding is usually confined to leaf margins. If the growing bud is injured, corn can suffer a significant loss in yield.

Host Crops

Armyworms feed on oats, wheat, fall rye, corn, barley, and forage grasses. Broad-leafed plants such as alfalfa, cabbage and turnips may also be attacked but the damage is minor. Fall and true armyworms may also feed on field and sweet corn, especially late-planted corn. They feed on both the leaves and ears.

Biology

The moths are active at night, feeding on nectar, mating, and searching for egg laying sites. Lodged plants provide a favourable habitat for moth concealment and egg laying. During June, adult female armyworms lay their tiny, white eggs at night, in clusters of up to 100, at the base of host plants. The eggs hatch in 1–2 weeks.

The larvae feed at night on the leaves and crowns of their hosts. During the day, they rest at the base of the host plants. There are 6 larval instars. It takes 3–4 weeks for the larvae to reach maturity.

When mature, the larvae construct pupal chambers a few centimetres below the surface of the soil. The pupae are about 20 mm (3/4 in.) long and reddish-brown in colour. Pupation may last about 2 weeks.

There are usually 2 generations per summer in Canada with the first generation doing the greatest damage in late June and early July.

Scouting Techniques

Influxes of moths from the south, during May and June, can be monitored using light traps or pheromone traps. Infestations of armyworm larvae are not easily detected by casual observation because the caterpillars hide during the day. However, black birds (grackles and red-winged black birds) commonly search for armyworms in small grain. Any field that has significant bird activity should be scouted.

In cereal and grass crops, check at least 5 areas of a field in late June. Pay special attention to patches of lodged plants and areas of grassy weeds. During the day, look for notched leaves on the plants. Late at night, with the aid of a flashlight, shake plants over a 1 square metre area and count the dislodged larvae.

If sampling for inactive larvae during the day, look under plant debris and lumps of soil, in soil cracks, and deep in the leaves. Day-time checking for armyworms is difficult.

Economic Thresholds

Localized infestations may require action. In cereals, control is usually necessary when larval densities exceed 10 larvae per square metre (sq. yd.). Only infested areas of the field should be treated. Spraying should be done in the evening when armyworms are feeding on the plants.

There is little benefit in applying an insecticide once the armyworm is nearly full grown, pupae are present, parasitism is extensive, or the crop is nearing maturity. By that time most of the damage will have been done.

Control Tips

Destroying grassy weeds, 1–2 weeks before seeding, will minimize the risk of attracting egg laying moths and subsequent infestations.

Bertha Armyworm

Heavy infestations may reduce yields because of defoliation and seed pod consumption. Crop losses due to pod feeding will be most severe if there are few leaves remaining on the crop.

Host Crops

Bertha armyworms prefer canola but also feed on rapeseed, mustard, alfalfa, flax, field peas, and potatoes. They are most damaging to canola and flax.

Biology

Bertha armyworms overwinter as pupae in the soil. The moths emerge from mid-June to mid-July. After mating, the female moths lay clusters of pin-head-sized eggs on the undersides of canola leaves when the plants are in bloom. Larvae usually emerge about 7 days later.

As the larvae mature, they usually darken in colour. Newly-emerged larvae are small, 3 mm (1/8 in.) long, pale green with a yellowish stripe along each side. The green larvae usually become pale-brown caterpillars. Most older larvae become large, velvety black caterpillars but others remain green or pale. Regardless of colour, the mature larvae are 4–5 cm (1.5–2 in.) long, with a light-brown head and a broad, pale-orange or yellowish stripe along each side. The head is light brown in colour with a yellowish-orange stripe along each side.

During hot, dry weather, the young larvae may be found feeding on the lower leaves or hiding under debris at the soil surface. The older larvae tend to feed both during the day and night. Larvae migrate from an infested field only when the food supply is

short or when the crop is over-ripe. After feeding is complete (usually by late August), the mature larvae burrow 5–15 cm (2–6 in.) into the soil where they pupate and overwinter.

Scouting Techniques

Regional pheromone trap monitoring indicates when field sampling is necessary. Generally, when the accumulated trap numbers exceed 500, there is a good chance that an outbreak will occur.

From a distance, infested canola fields look pale-white because the larvae eat the outer green layer of the stems and pods exposing white tissue. Checking for larvae can be done from mid-June through late July. Because their distribution within a field may be spotty, several one square metre (sq. yd.) spots should be sampled.

Shake the canola plants to dislodge the larvae and then count all the larvae on the ground over a 1 square metre (sq. yd.) area. It is important to check under leaf litter, lumps of soil, and debris when counting the larvae. Use the average number of larvae per square metre (sq. yd.) within each field to determine if the economic threshold has been exceeded.

In other crops, examine any cruciferous weeds present. Larvae may not attack the crop until all of the weeds are consumed.

Economic Thresholds

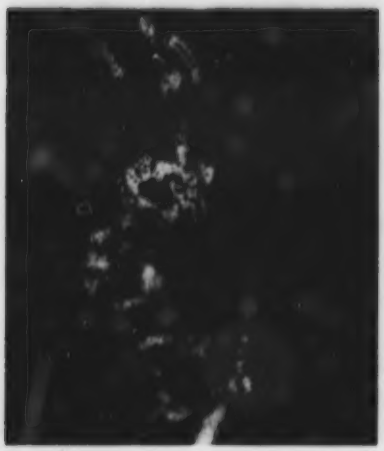
Control is usually recommended when larval population densities exceed 20–30 larvae per square metre (sq. yd.) in canola. The threshold level ranges from 10–35 per square metre (sq. yd.), depending on the value of the crop and the cost of control. For detailed information on economic injury levels for bertha armyworm in canola, consult the *Guide to Crop Protection*. Economic thresholds for this pest in flax have not been determined.

Control Tips

Fall tillage and low winter snowfall levels may reduce the number of pupae surviving to spring. Seeding early may avoid moth egg laying flights.

Application of insecticide, if required, should be made in the evening when the larvae are actively feeding on the upper portions of the plant.

Cabbage Maggot



Cabbage maggot (sometimes called canola root maggot) is common throughout the canola growing areas of the Prairies.

Host Crops

This insect can be a serious pest of canola and other cruciferous crops, including mustard, cabbage, rutabaga, radishes, cauliflower and broccoli. Polish canola is more susceptible than Argentine canola.

Biology

The adult stage is a fly that emerges in the spring or early summer from overwintering cocoons in the soil. It looks like a common house fly but is smaller and ash grey in colour with a dark stripe along the back of the abdomen. A second adult emergence may occur later in the summer as the first generation completes its life cycle. Thus, maggots can be found throughout most of the growing season.

Each female fly will lay 50 to 200 eggs. The eggs are small (1 mm or 1/20 in.), white and elongated. They are laid at or near the base of host plants, usually just beneath the soil surface. The larval stage is a small, 6–10 mm (1/4–1/2 in.) long, white, legless maggot. When the eggs hatch, the maggots move down into the soil and begin feeding on small roots and root hairs. Eventually, they tunnel into the plant's taproot. Feeding will last for 3–4 weeks, after which the maggots pupate in the root or in the soil. The pupae are elongated and brown, resembling small wheat kernels. Pupation occurs in the top 5–20 cm (2–8 in.) of soil.

Scouting Techniques

Cabbage maggot infestations are more severe after a cool, wet spring. Larvae feed on feeder roots and tunnel into the taproot, producing brown streaks on the root. The lower leaves of infested plants often turn yellow, with severe damage resulting in arrested

plant growth. Feeding damage may also promote disease, causing further stress on the plant.

The adults are most abundant in canola during June and early July. Heavy infestations in canola and mustard can delay blooming and cause severe lodging and yield losses. Infested canola roots are often darker than normal roots.

In the spring, use sticky traps or sweep nets to look for the adult fly. When searching for maggots later in the season, carefully pull several host plants with the taproot intact. Use a hand lens to look for evidence of maggot feeding on the root (feeding scars). Maggots will tunnel into the root and create channels along the outside. Check several plants in at least 5 locations in the field.

If the maggot is present, you may need to wait several minutes for it to emerge and show itself or you can cut into the root to assess maggot damage. Later in the season, you may have to screen the soil around the root to see if there are any puparia present.

Economic Thresholds

No action thresholds are available for cabbage maggots.

Control Tips

A moderate increase in canola seeding rates may reduce damage and yield loss experienced from maggot feeding. Heavier canola plant densities result in smaller basal stems that are less attractive to egg laying females.

Tillage prior to seeding can reduce the level of emergence of adult flies by moving pupae nearer to the soil surface where they are more susceptible to attack by natural enemies. Fall tillage can expose the pupae to severe environmental conditions over the winter. However, fall tillage can leave soils susceptible to erosion and should be used cautiously.

To avoid or reduce losses, producers should either grow crops that are not susceptible to the insect or Argentine canola varieties.

Control cruciferous weed species because they can act as alternate host plants and result in increased over-wintering populations of cabbage maggot.

Polish canola varieties are more susceptible to maggot feeding than Argentine types. Yield losses as high as 50% for Polish and 20% for Argentine canola varieties have been reported.

Cereal Aphid

(Similar in appearance to the potato aphid on page 32)

The cereal aphid is the main vector for barley yellow dwarf virus on the Prairies. Infected aphids can reduce yields of dry forage and protein of oats and barley by over 50%.

Host Crops

Cereal aphids feed on cereals and grasses.

Biology

This aphid, also called the bird cherry oat aphid, is dull to dark-olive-green, with a reddish-orange patch between and at the base of the tail tubes. It is about 2 mm (1/16 in.) long. The legs and short cornicles are pale-green with black tips. The antennae are long and black. It is found in colonies or scattered on lower leaves, stems, and roots of cereals and grasses.

The cereal aphid is most easily confused with the corn leaf aphid. The cereal aphid has a rounded, bulblike, body shape; the corn leaf aphid appears almost rectangular.

Scouting Techniques

When surveying for aphids in small grains, make several counts throughout the field, prior to heading. Farmers often become alarmed after checking a few plants along the margins, especially near shelterbelts where populations are high. Counts should be at least 50 m (150 ft.) apart and observations should be made well into the centre of the field. Carefully examine 20 stems in each of five areas of the field, for a total of at least 100 stems per field.

Look for symptoms of damage, including leaf discolouration in host plants. Severe infestations may appear as large, bronzy or brown patches in the field, often easily visible from the road. Later in the season, these patches may appear as thin stands.

In younger plants, aphids may cluster near the base of the plant, on the

upper sides of the leaves. In older plants, check inside leaf whorls for the aphids. Collect plants by cutting the roots below the crown.

Agronomists routinely take stem samples for aphid counts. Cut the stem close to the ground and then hit it sharply against a stiff piece of white paper or into a white pan. This dislodges the aphids so they can be counted.

While counting aphids, note the presence or absence of predators, parasitized aphid mummies, or aphids killed by fungus.

Economic Thresholds

The threshold for cereals is 12–15 cereal aphids per stem prior to the heading stage. The threshold for canaryseed is 20–30 cereal aphids per tiller between the heading and soft dough stage.

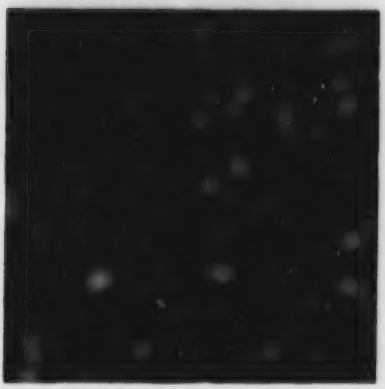
Control Tips

Early-seeded crops may grow and become vigorous, passing the susceptible stage before aphid populations reach damaging levels.

Volunteer grain control is critical. When controlling aphid-infested grasses or volunteer grains, either by mechanical means or using a herbicide, the aphids should first be treated with an insecticide to prevent them from moving out of the localized, infested areas.

If only mechanical control is used on the grasses and volunteer grains, the first 10–20 rows of adjacent plantings should be treated to control aphids as they move out of tilled areas.

Colorado Potato Beetle



Host Crops

Potatoes, tomatoes, dry beans, cabbage, pepper, pigweed, smartweed, ground-cherry, thistle, lamb's quarters, and other plants in the nightshade family.

Biology

The adult beetle is fairly large, about 9.5–10 mm (3/8 in.) long and 6.5 mm (1/4 in.) wide. Its rounded outer wings form a hard "shell" marked with 10 alternating black and yellow stripes. The head is a tan-orange colour, with black markings. The yellowish-orange eggs are found in clumps of 20–40 on the underside of leaves. The fat, soft-bodied larva has a smooth-skinned, creamy-reddish-tan, humped-back body with 2 rows of black spots along each side.

Adult beetles overwinter in the soil or under litter in fields, gardens, or fence rows. They begin to emerge from their overwintering sites in late May to search for suitable host plants where the females feed and lay eggs on leaves.

The eggs hatch into larvae in 4–15 days, depending on temperature. Small, dark grubs, about 2.5 mm (1/8 in.) long, emerge from the eggs. The

Feeding on the leaves and stem tips can limit tuber development in potatoes. Leaf feeding has the greatest effect if it occurs within 2 weeks of peak flowering. Uncontrolled populations can completely defoliate potato plants and cause a total loss of tuber production. Potato beetles may be vectors of spindle tuber, bacterial wilt, and ring rot.

larvae begin to feed on leaves during June, often in exposed locations on the upper part of the plant. After 2–4 weeks of feeding, the larvae are fully-grown. Mature larvae drop to the ground, burrow 7.5–15 cm (3–6 in.) deep and form a pupal "chamber" by beating against the soil around them until it is hard and compact. There are reports that it may burrow down 1 m (40 in.) in light sandy soil.

Larvae then moult once to become yellow-coloured pupae. The new adults emerge 2–3 weeks later, depending on temperature, and dig their way to the surface. The new adults feed on leaves, then mate and lay eggs. There is usually one brood of larvae per year.

Scouting Techniques

Monitoring should begin when plants begin to sprout early in the season. Larvae and adults are easily seen feeding on the leaves.

Inspect 30 linear metres (100 ft.) of row for every 30–40 acres of field size. Do this by visually inspecting 3 m (10 ft.) of row at 10 different, random sites. Never inspect fewer than 10 sites, regardless of field size. Do not deliberately choose a particular section of row. One way to sample randomly is to walk a zig-zag path across the field without looking at plants for injury, then stop and make your inspection. Spread your sample sites across the entire field. Walk a different path every week.

Inspect each 3 m (10 ft.) row section for larvae. Record the number of plants in each section that have at least one larval colony. Do not count larval numbers, just the plants with larvae. Total the number of infested plants for each set of 10 samples. If you inspect more than one set of 10 samples, determine the average number of infested plants per 30 m (100 ft.).

Economic Thresholds

Treatment is usually necessary in commercial potato fields when about 10% defoliation is found. Potatoes can tolerate up to 20–25% defoliation before yields will be affected.

Consult the provincial *Guide to Crop Protection* for detailed information on economic thresholds.

Control Tips

Time the first treatment when 15–30% of the first egg masses have begun to hatch.

Insecticide resistant populations have been identified on the Prairies. Consult your provincial agricultural representative for current information on dealing with such populations.

Cutworm

Cutworms can be a serious problem in many field crops. There are many different species involved but two of the most common ones are the red-backed cutworm and the army cutworm.

Host Crops

The red-backed cutworm feeds on practically all field crops, vegetables, and home garden plants. It is best known for its feeding on cereals, flax, sugar beets, canola, and mustard.

The army cutworm feeds on the foliage of wheat, oats, barley, mustard, flax, alfalfa, sweetclover, field peas, cabbage, sugar beets, corn, oats, potatoes, various weeds (notably stinkweed) and grasses. Almost any crop, present during the early spring, could be a potential host.

Biology

Cutworm larvae have 4 sets of abdominal prolegs and curl up when disturbed. Red-backed cutworms are dull-gray to brown in colour and have a pink, red or reddish-brown top-stripe that extends the entire length of the body. The top-stripe is divided by a dark line and bordered by darker bands. The head is yellowish-brown. Army cutworms are pale greenish-gray to brown in colour. They have pale stripes down the back and a mottled pattern. They also have a lighter band along the sides.

Cutworm moths may lay several hundred eggs on their host plants. After the eggs hatch, the larvae feed on the host plants. They moult several times, eventually reaching about 5 cm (2 in.) in length. The larvae tunnel into the soil to form earthen cells where they pupate. The new moths emerge, exiting through the soil using the old larval tunnels.

Some species overwinter as eggs (e.g., the red-backed cutworm); others, as larvae or pupae. Still others do not overwinter in the Prairies but rather reinvade annually from the USA, aided by southerly winds. Most of our pest species have only 1 or 2 generations per year.

Scouting Techniques

Inspect the seedlings on, at least, a weekly basis, from mid-May to mid-June. When notched, wilted, dead, or cut-off plants (weed or crop seedlings) are seen, dig around the roots of the plant to see if any cutworms are present.

To collect cutworm larvae, a garden trowel and a soil sifter are useful tools. Cutworms may be found down to about 5 cm (2 in.) below the soil surface. The small, worm-like larvae curl up or attempt to hide in the debris. Pupae may also be collected in this way. The larvae and pupae can be reared to adult moths if necessary for species determination.

Because cutworm moths, like most moths, are nocturnal and attracted to light, the adult population can be monitored using light traps. Sex attractants also can be used to trap adult cutworm moths in commercial or home-made pheromone traps.

Economic Thresholds

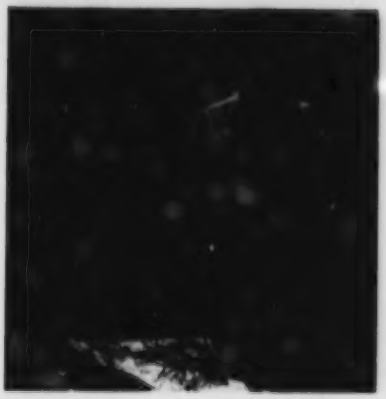
Cutworm control in cereals is usually necessary when cutworms destroy 3–10% of the crop or when cutworm populations exceed 2–5 cutworms per 100 plants or 3–4 cutworms per square metre (sq. yd.).

Five army cutworms per square metre (sq. yd.) can destroy a mustard field. Ten or more army cutworm larvae per square metre (sq. yd.) can cause significant damage to flax. For established stands of alfalfa, 4 or more army cutworms per 0.1 square metre (sq. ft.) may cause significant losses. Because newly-seeded stands have fewer root reserves, only 2 larvae per 0.1 square metre (sq. ft.) can cause economic damage. Twelve red-backed cutworms per square metre (sq. yd.) in flax seedlings can cause a 10% reduction in yield.

Control Tips

Best results occur if insecticide applications are made in the evening.

Diamondback Moth



The diamondback moth is an occasional pest of canola across the Prairies. Most damage is caused by feeding on the surface of filling and maturing pods.

Host Crops

On the Prairies, diamondback moths are most frequently observed in canola fields. Other favoured food plants include broccoli, Brussels sprouts, cabbage, cauliflower, horseradish, commercial mustard, radish, and turnip. They also feed on stinkweed, shepherd's purse, and wild mustard.

Biology

The moths are small, 12 mm (1/2 in.) long, with an 18–20 mm (3/4 in.) wing-span. They are grey or brown, with light-tan marks on the margin of the forewing. While at rest, the wings are folded, roof-like, over the body. They hold their antennae forward when at rest.

This pest does not overwinter in the Prairies. It moves in from the USA on strong south winds on an unpredictable basis. A female may lay 100–300 scale-

like, greenish-white to creamy-yellow eggs. The eggs are laid singly or in small groups. The mature larva is a small, pale-green caterpillar, about 8 mm (5/16 in.) long. It has a narrow head and hind-quarters (i.e., somewhat spindle-shaped). With 5 pairs of legs on the rear half of the body. The tail end of the larva has a forked appearance.

Larvae of the diamondback moth feed on the foliage from the seedling stage to harvest. They can greatly reduce the quality and yield of the crop. Older larvae feed on flowers, young pods, and the surface tissue of stems and mature pods, usually from mid-July to early August.

The larvae pupate in a loose, silken cocoon on the plant, with the new adult moths emerging a week or so later.

Scouting Techniques

When monitoring for diamondback moth larvae on canola, gently pull out a canola plant and count all the larvae present. Count larvae by taking whole plants and knocking on the hood of a car or on a light coloured jacket. The leaves of infested plants will be shot-holed.

Pheromone traps can be used to monitor moth activity. Although these traps cannot predict the size of an outbreak, the trap counts can provide an early warning of an infestation.

Economic Thresholds

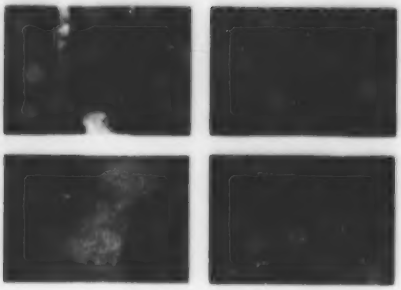
It takes a severe infestation of small larvae to cause appreciable damage. Damage is most noticeable during dry summers. The action threshold for diamondback moths in podded canola is 200–300 larvae per square metre (sq. yd.). This is roughly equivalent to 20–30 larvae per 0.1 square metre (sq. ft.). There have been reports of up to 415 larvae per plant during severe infestations. If pod damage begins to show when the larvae are still small and numerous, control measures are definitely warranted.

Note that, if the moths are blown in from the south early or if the canola is sown late, the larvae may feed on the developing buds of canola. If this happens, the economic thresholds would be much lower than when larvae feed on the pods.

Control Tips

Check with provincial agricultural representative for timing of applications.

European Corn Borer



This pest is a serious threat to corn producers across the Prairies, reducing yield of grain and silage corn and making sweet corn unmarketable.

Host Crops

Sweet corn is the preferred host. Grain and silage corn are also attacked.

Biology

Mature larvae are about 2.5–3 cm (1–1.2 in.) in length, white to tan-grey in colour, and covered with rows of small brown spots. The larva has a brown head and faint, reddish stripes that run the length of its body.

During the late-spring, the overwintered, full-grown larva chews an exit hole in its corn stalk and returns to its tunnel to spin a cocoon in which to pupate. Moths usually begin to emerge from corn debris in mid-June. They often gather in areas of dense, grassy vegetation bordering corn fields. This vegetation provides a moist, damp area, optimal for moth survival and egg laying. The resident moth population may be increased by moths flying in from the south in some years. Peak egg laying and flight occur in early to mid-July, during calm, warm nights. Female moths will lay up to 500–600 creamy-white eggs, in batches of 15–25 eggs, on the undersides of corn leaves, near the midrib. The egg masses are about 6 mm (1/4 in.) in diameter.

The eggs hatch within a week (mid-July through early August). The young larvae disperse and feed on leaves and work their way to the whorl of the plant. Pinholes or shotholes are signs of borers already moving into the plant. During later stages of borer development, most larvae enter the tassel, stalk, and ear shank, but they may also feed on the silks, kernels and cobs. Nearly-mature larvae bore into the stalk by late summer to overwinter.

Scouting Techniques

Beginning in early-July or when corn is about 0.5 m (2.5 ft. high), corn growers should check their fields on a weekly basis. Move well into the field before you begin. Check 20 plants in each of 5 different areas of the field to get a reliable idea of the infestation level.

Egg masses can be seen on the lower surface of the leaves, usually near the leaf mid-rib. The eggs are white when laid. Just before hatching, the egg mass darkens because of the darkening head capsules of the larvae. This sign of imminent hatching can be used to time subsequent treatments.

The first indication of larval corn borer activity is the so-called "windowpane" feeding injury to the foliage by the very early larval stages. Later, shot-holes appear in the leaves. They are caused by the early larvae tunneling through the emerging whorl.

As the larvae increase in size, they begin tunneling into the stalks or midribs of the corn foliage. The young larvae feed on leaves and usually can be found in the tassels, beneath the husks, and between the ears and stalks. The older larvae bore into the stalks and ears where they overwinter.

Infested corn stalks may break or have weakened tassels that are easily broken by the wind. All of the above-ground parts of corn plants can be damaged by the larvae.

If 3 or more moths are observed when walking through a grassy field edge, egg laying in the adjacent corn field is or was probably intense. Close inspection for egg masses or newly-hatched larvae should begin immediately.

Entomologists use blacklight traps or pheromone traps to monitor adult corn borer activity.

Economic Thresholds

Economic loss in grain and silage corn may occur when 50% of the plants have shot-holes in the leaves, caused by young corn borers. Lower infestation levels (e.g., 15% of the plants shot-holed) may reduce the quality of sweet corn.

Control Tips

Ploughing down corn stubble and residues in the fall will reduce the number of overwintering larvae by up to 99%. Mowing after harvest may be an alternative to ploughing down corn stubble. Chopping corn stalks for silage will remove and destroy the larvae. Burning is not as effective because some borers will survive in stalks not completely burned. Dwarf corn seems to be less susceptible to corn borer infestation than tall corn.

High clearance sprayers or aircraft, fitted with multiple nozzles to ensure thorough coverage, are most effective when high water volumes are used.

Flea Beetle

Flea beetles are common pests of cruciferous crops on the Prairies. Often appearing in large numbers, they can completely destroy young stands of canola.

Host Crops

Host plants include cabbage, turnip, cauliflower, Brussels sprouts, canola, sugar beets, tomatoes, horseradish, radish, potatoes, flixweed, wild mustard, stinkweed, lamb's quarters, and other crucifers.

Biology

Flea beetle eggs are tiny, (0.4 mm or 1/20 in.), elongated, and yellow. The larvae are a dirty-white colour with brown heads. When mature, the larvae are slender, up to 6 mm (1/4 in.) long, with 3 pairs of short legs on the thorax. The pupae are white and about 2.4 mm (1/8 in.) in length.

The adult beetles are small, blackish beetles with a metallic or bright blue lustre, measuring about 2–3 mm (1/8 in.) in length. Some species are striped; others plain.

Flea beetles overwinter as adults under leaf litter, along fence rows, and in shelterbelts and woodlots. They become active in mid-to late May, feeding on volunteer canola and mustard or on weeds. Later, the flea beetles move to seedling canola or other cruciferous crops.

After mating and egg laying in early June, the overwintered adults begin to die off. The young larvae feed on the roots of the developing canola for 3 or 4 weeks. They are present from about mid-June to late July.

After feeding, the larvae form earthen cells in which they pupate. The new adult flea beetles begin emerging in late July and early August. These adults feed on the green tissue of suitable host plants that are still present. Feeding may continue into mid-October. However, by mid-September, most adults have usually entered a dormant, overwintering stage. Only one generation of flea beetles is produced each year.

Scouting Techniques

Flea beetles chew small holes in the cotyledons or leaves, giving a "shot-hole" appearance. Losses include stand thinning, smaller and weaker plants, and delayed plant development. All of these losses contribute to reduced yield, especially if the weather is hot and dry.

Canola seedlings can withstand significant leaf area removal in the cotyledon stage under good growing conditions without significant reduction in yield. However, with heavy and continuous attacks, seedlings may wilt and die. Heavy infestations may destroy the entire crop and re-seeding may be necessary. Once the crop reaches the 3– or 4-leaf stage, the plants are usually well established and can outgrow the feeding damage. Also, the number of adult flea beetles often begins to decline at that time.

Flea beetle abundance and related damage can be assessed in a variety of ways. One can count the number of infested plants per metre of crop row, collect all beetles down the centre row of a test area, or count the number of feeding holes on collected leaves. However, the simplest method is to sample a representative series of plants and rank each as to the % damage of the cotyledon leaf surface. If you rank, for example, 100 plants, you can total the % damage for all of the plants and divide by 100 to get an average % damage.

Economic Thresholds

The threshold is when, on average, 25% of the cotyledon surface is damaged.

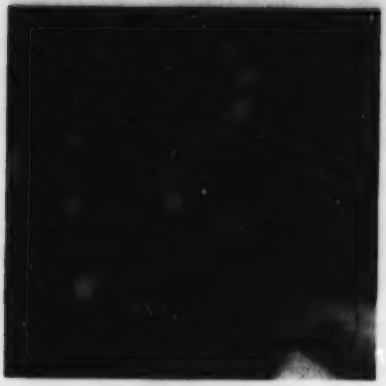
Control Tips

Clearing cruciferous weeds from shelterbelts and headlands may help by removing alternative sources of food. Removing vegetative trash from fields and ditches may also reduce overwintering sites.

Early planting in stubble, at a high seeding rate, will minimize the damage caused by flea beetles. Planting into stubble may also reduce feeding damage because of the cooler microenvironment created when the stubble shades the surface soil. The cooler surface temperatures may slow down flea beetle activity, reducing damage.

Flea beetles can be controlled by using seed treatments, granular seed placed insecticides, foliar insecticides, or combinations of these treatments.

Grasshopper



Infesting field crops, gardens, pastures, grasslands, and nurseries, grasshoppers can cause millions of dollars of damage during outbreak years.

Host Crops

Grasshoppers usually feed on forbs and grasses but, when abundant, they often will feed on vegetables and field crops, especially wheat, oats, and barley. During severe outbreaks, grasshoppers tend to eat anything "green", including trees and shrubs.

Biology

Grasshoppers have one generation per year in Canada. Egg-laying usually begins in late July and continues into the fall. The egg pods are placed by the female in a cavity in the soil. Most grasshoppers overwinter as eggs in the soil. Egg hatch usually begins in late April or early May, peaks about mid-June, and is complete by late June. Hatching begins when the soil temperature has been 15–16° C for about 200 hours.

Newly-hatched grasshoppers are about 5 mm (1/4 in.) in length. These nymphs resemble the adults but have wing pads instead of wings and, therefore, cannot fly. There are usually 5 or 6 nymphal instars. Grasshopper nymphs mature in 35–55 days. The adults may live for 4–6 weeks after mating and egg laying.

Scouting Techniques

Many agronomists use 'foot-square' counts to rate their fields. This is simply the number of grasshopper nymphs that jump from a square-foot area as you walk towards it.

To do a field survey, start at one corner of the field, walk diagonally past the centre of the field, then turn and walk straight out to one side of the field. Make at least 20 of these square-foot counts in a survey. Dividing the total grasshoppers counted by 2 will give the approximate number of grasshoppers per square metre (sq. yd.).

Economic Thresholds

When populations exceed 8–12 hoppers per square metre (sq. yd.), control is usually warranted.

Control Tips

Cultivation of fields in the fall may help control grasshoppers by exposing some of their eggs to predation, sun, wind, and frost. Deep tilling buries the eggs so deep that, upon hatching, the nymphs cannot reach the surface. However, the impact on the following years' grasshopper population will be minimal and soil and moisture conservation must also be considered.

Farmers practicing reduced tillage should be aware of the increased potential for grasshopper problems in their fields.

Early seeded, vigorous crops develop rapidly before the grasshopper eggs hatch. These crops can then tolerate feeding better than late seeded crops.

Hopper baits, containing an insecticide formulated on bran, are another option. The main benefits seem to be lower cost, less insecticide used, very specific to grasshoppers, and avoidance of insecticide drift.

Insecticide applications are most effective and the costs are lower when they are applied after the eggs hatch and while the nymphs are still concentrated in their breeding areas.

Often, grasshopper nymphs can be sprayed in roadsides, headlands and field margins before they move into a field crop, vegetable garden or nursery.

The lowest dosage given on the container label should be used when the grasshoppers are small and the vegetative cover is low.

Hessian Fly

Substantial yield reductions in grain and forage occur when these crops are heavily infested with this pest. Toxins released during feeding interfere with normal wheat growth.

Host Crops

Wheat (spring and winter) is the preferred host of the Hessian fly. Barley, oats, triticale and rye are generally considered resistant. Wild grasses (e.g., quackgrass, western wheatgrass, rye grasses, timothy) are also hosts.

Biology

There appears to be a spring and a fall generation. For winter wheat, the fly invades fields in September and establishes the fall generation. A second generation occurs the next spring. The insect survives the summer as a 4th-instar larva in the "flaxseed" stage in infested wheat stubble. This shiny-brown, seed-like puparium can be found at the base of old plant crowns. It also may occur in straw, near the nodes, behind the leaf sheaths.

Rain will trigger fly emergence in early September. Farmers who plant winter wheat early will have young wheat in the seedling stage when the flies emerge. The potential for infestation and damage to sensitive, young plants is high.

Young wheat plants or tillers are preferred for egg laying. Typically, the eggs are laid in rows, looking like a string of "hot dogs", when viewed with a magnifier.

The reddish, 1st-instar larvae move from the empty egg shells and crawl downward, gradually reaching the base of the leaf. Here, between the leaf and tiller, the young larva begins to feed, with its head in a downward position. A single larva, feeding for just 3 days, is capable of stunting a young wheat plant or tiller. The larvae feed for about 2–3 weeks. They then form the puparium that resembles a "flaxseed". The non-feeding 4th-instar larva overwinters within this structure.

Some mortality occurs each winter, depending on many factors, including temperature, moisture and natural enemies. In the spring, development resumes and the larva transforms into a pupa, still inside the puparium. The

spring emergence of adult flies follows within a few days. The adult life is short, lasting an average of only 2–3 days.

Scouting Techniques

Winter wheat plants infested in the fall can easily be recognized by their darker than normal colouration and leaves with unusually broad blades. Young plants or tillers infested in the fall often die during the winter. Plants attacked in the spring have shortened and weakened stems that may eventually break, causing plants to lodge near harvest.

Scouting provides information useful in planning next year's crop rotations. Wheat can be checked just after emergence. Hessian fly is easiest to detect in the "flaxseed" stage. Look for areas of poor stand and stunted plants in the field.

Collect about 50 stems from throughout the field, avoiding field edges. Examine the base of these plants by pulling back the sheaths of several leaves and looking for the dark-brown, flaxseed-like puparia.

Economic Thresholds

When a field becomes infested, control measures will not work. Control is based entirely on prevention.

Control Tips

The use of resistant varieties alone or in combination with delayed planting dates and destruction of volunteer wheat has greatly reduced risks associated with this pest.

Flies emerging in late-summer or early-fall will lay eggs on any available host plant, including volunteer wheat. If this wheat is destroyed, the earliest emerging flies have fewer egg laying sites. By harvesting wheat early and discing under or burning stubble, much of the population can be eliminated. Discing the stubble under completely is more effective than burning.

Because the Hessian fly is a weak flier, rotation of crops over a wide area can help to reduce infestations. Never plant wheat in the same field 2 years in a row, especially if no-tillage practices have been followed.

Because the fly lives for only a short time in the fall, delayed planting of wheat can help eliminate the overlap between the presence of flies and newly emerged winter wheat. Winter wheat planted in August will most likely be susceptible to attack. Winter wheat planted in September will likely be fly-free.

Lygus

Lygus bugs have piercing-sucking mouthparts that physically damage the plants by puncturing the tissue when they suck plant juices. The plants also react to the toxic saliva that the insects inject when they feed.

Host Crops

Lygus and other plant bugs feed on weeds (chickweed, dandelion, red clover, red root pigweed, lamb's quarters, plantain, golden rod, asters), forage crops (red clover, alfalfa), oilseed crops (canola, mustard, sunflower), vegetables (asparagus, beans, beets, cabbage, cucumbers, peppers, potatoes, sugar beets, tomatoes, turnips) and fruits (strawberries, apples).

Biology

Adult lygus bugs are about 5 mm (1/4 in.) long and 2.5 mm (1/8 in.) wide, oval, and slightly flattened. They vary in colour from pale green to reddish-brown and have a distinctive triangle or "V" mark about one-third of the distance down the back, just in front of the wings. The legs and antennae are relatively long.

The young nymphs are pale-green in colour and look like aphids except that they are more active. Colour in the older nymphs becomes more variable and is similar to that of the adults. The older nymphs develop prominent black dots on the top of the thorax and abdomen.

The adults overwinter, hidden in protective hedgerows, fallen leaves and other plant debris. Emerging in mid-April to late May, they feed on host weeds. The eggs are laid on the stems and petioles of these hosts. About 10 days later, the eggs hatch and the nymphs feed.

The 1st-generation adults appear in mid-June to mid-July. They leave the host weeds, dispersing into adjacent crops. The 2nd-generation nymphs

feed on the host plants during August, causing economic damage. The adults produced by this generation emerge in late August and September. A smaller 3rd generation may emerge in September.

Scouting Techniques

Monitoring for lygus in most crops usually involves a combination of sweeping nearby host weeds, using a standard insect sweep net, and visually inspecting crop plants. Tapping blossoms over a shallow, white pan will reveal any young nymphs present.

Monitoring for lygus in canola involves sweeping either with 10 sweeps in 15 locations or 20 sweeps in 10 locations in the field. The locations should be representative of the field and spaced about 50 metres (150 ft.) apart. For those people who may have trouble separating lygus nymphs from aphids, a hand magnifier is recommended.

Economic Thresholds

In canola, there are 2 economic thresholds: (1) when sampling up until petal fall is complete, the threshold is an average of 15 lygus per 10 sweeps and (2) if sampling is within 4–5 days after petal fall, the threshold is an average of 20 lygus per 10 sweeps.

In alfalfa grown for seed (not forage), an average of 5 nymphs per sweep or 1 adult per 2 sweeps indicates an economic infestation. Control is not recommended in alfalfa grown for hay.

Control Tips

Reducing adjacent weedy areas that serve as overwintering sites for the adults and reducing weeds in crops that serve as early season hosts will lower local populations.

Because plant bugs have 2 generations throughout most of the their range in the southern Prairies, 2 insecticide treatments may be necessary.

If insecticide is required during the bloom stage, early morning or late evening applications should be targeted to minimize possible bee kill. In canola, spraying is best done at 'post-petal fall' to minimize the effects of the insecticide on pollinators.

Painted Lady Butterfly

This caterpillar has been an occasional pest of sunflowers. Sporadic outbreaks in the Prairies have resulted in localized severe damage of cultivated fields.

Host Crops

Larvae feed primarily on Canada thistle foliage, leaving the stem and midrib. Feeding temporarily inhibits the weeds but new growth usually develops in the fall. They also feed on about 60 other hosts, including sunflowers and canola.

Biology

Adults migrate into the Prairies from overwintering sites in Mexico, arriving in early June. There is no evidence that they can survive our cold winters. This butterfly normally prefers to lay eggs on Canada thistle plants but under some conditions, will lay eggs on other plants as well. Larvae feed on the leaves producing a loose webbing and, if numerous, can completely defoliate a plant. The larvae are up to 30 mm (1.25 in.) long and dark purple to black in colour. They have long spines on each segment of the abdomen.

Scouting Techniques

While scouting sunflowers, watch for the appearance of this pest. If populations seem heavy, sample about 100 scattered plants, noting the percent defoliation on each. Divide the total percent defoliation by the number of plants sampled to obtain an estimate of percent defoliation for the field.

Economic Thresholds

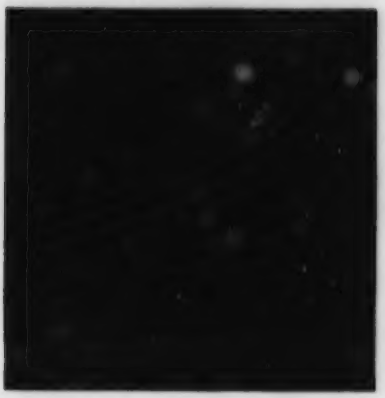
The threshold is 25% defoliation in sunflowers.

Control Tips

Heavy parasitism of this pest and high infections of bacterial disease usually limit the damage that the larvae can inflict on sunflower crops.

Because this occasional pest is usually limited to small, scattered patches within a field, insecticide treatments are rarely justified.

Pea Aphid



The pea aphid is the most important insect pest of field peas in the Prairies.

Host Crops

Field peas, alfalfa and clovers are the main hosts of the pea aphid. Other legumes, including vetches, sweet peas, trefoil and dry beans, are also attacked.

Biology

Adult pea aphids are soft-bodied, slow-moving, and range in colour from light to dark-green. They are pear shaped, about 3 mm (1/8 in.) long and 1.5 mm (1/16 in.) wide, with long slim legs. The antennae of the pea aphid show narrow dark bands at the tip of each segment. The nymphs are smaller but closely resemble the adults.

Pea aphids overwinter as eggs on leaves and stems of perennial legumes (e.g., on the crowns of clover or alfalfa). In the spring, when plants resume growth, a small, light green, wingless female hatches from each egg. These aphids, which are all females and are called "stem mothers", can reproduce without mating. They feed on the growing plants and give birth to female young. Some aphids of the 2nd and 3rd generations become winged and migrate to field peas and other acceptable host plants. There they feed and produce wingless females that give rise to winged and wingless females.

Aphids develop from birth to maturity in 5–50 days depending on the weather. All pea aphids are female throughout spring and summer. A summer female can produce 50–150 young during her life. If the host crop is cut during spring or summer, the winged aphids leave to search for new plants on which to live.

In late September or October, winged males and wingless females are produced. These mate and the females lay eggs on leaves and stems. There may be 7–15 generations per year.

Scouting Techniques

The key to aphid management is early detection through careful, periodic scouting. A 10 or 20X hand lens is needed to identify aphids when scouting in the field. The fields should be sampled weekly for aphids, from the time of plant emergence to harvest. Populations may increase 2–3X on a biweekly basis.

If strong southerly winds occur over a period of several days, in the early summer, this may indicate a subse-

quent outbreak of aphids. Remember that you have to look over the entire field. If the aphids fly in, they may land anywhere in the field. If they migrated in from an adjacent field, chances are that they will be found on the edge of the new field.

Counts should be at least 50 m (150 ft.) apart and observations should be made well into the centre of the field. Carefully examine 20 stems in each of 5 areas of the field, examining at least 100 stems per field.

Look for symptoms of damage, including leaf discolouration in host plants. Severe infestations may appear as large, bronzy or brown patches in the field, often easily visible from the road. Later in the season, these patches may appear as thin stands.

In younger plants, aphids may cluster near the base of the plant, on the upper sides of the leaves. In older plants, check inside leaf whorls for the aphids.

Some agronomists routinely take stem samples for aphid counts. Cut the stem close to the ground and then hit it sharply against a stiff piece of white paper or into a white pan. This dislodges the aphids so they can be counted.

Economic Thresholds

Sampling to determine aphid density should be done when 50–75% of the pea plants are in flower. The threshold in Century peas is 2–3 aphids per 20 cm (8 in.) of plant tip at flowering. Trapper peas can tolerate higher levels. Plants infested before the flowers open recover without loss of yield.

The threshold in alfalfa is 10 aphids per stem at 2 weeks before hay cuttings.

Control Tips

Any practice that reduces crop stresses should be emphasized (e.g., good seed bed preparation, proper seeding rate, fertilization, irrigation where available). On irrigated alfalfa, control may be unnecessary if adequate water is provided to the plants. Early-seeded crops grow and become vigorous and pass the susceptible stage before aphid populations reach damaging levels.

Avoid any unnecessary insecticide applications to let ladybird beetles, lacewing larvae, syrphid fly larvae, damsel bugs, big-eyed bugs, minute pirate bugs, and parasites keep populations in check.

Potato Aphid

These aphids damage potatoes by direct feeding, depositing large amounts of honeydew on the leaves, and spreading plant diseases. Occasionally, they become so abundant that their feeding weakens and stunts the plants.

Host Crops

Flax, potatoes, tomatoes, lettuce, peppers, sunflowers.

Biology

These small aphids (about 5 mm or 1/4 in. in length) are pale green (darker along the centre line) and have prominent, dark tipped tail tubes. Viewed through a hand lens, the tips of the tail tubes have a netlike appearance.

Pink and green forms of the potato aphid are found in potatoes. Potato aphid colonies are made up of adults and their offspring, closely clustered together.

The potato aphid overwinters on roses, raspberries, and strawberries.

Scouting Techniques

Monitoring should be done weekly. Potato aphid infestations are generally scattered over the entire plant. Early season infection stunts plant growth. Infected seed potatoes will not produce marketable potatoes. An infected Russet Burbank potato often has phloem net necrosis, a brown discolouration inside the potato that reduces quality. The brown discolouration is most intense at the stem end but may extend well into the tuber.

Potato aphids are also responsible for the spread of potato leafroll virus.

Economic Thresholds

The threshold in flax is 2–3 aphids per plant at full bloom or 8 aphids per plant at the green boll stage. In potatoes, no economic thresholds have been developed.

Control Tips

Weeds along ditch banks, roads, in farm yards, and other non-cultivated areas contribute directly to the aphid problem. Mustards may serve as early season host plants where aphid populations increase before spreading to other host plants. Plant disease-free seed to reduce the incidence of potato leafroll virus. Plant early to produce larger tubers.

Sunflower Beetle

Feeding by adult beetles and larvae may result in extensive damage, causing poor seed set or seed filling, reduced yields, and delayed maturity.

Host Crops

Sunflower beetles feed on native and cultivated sunflowers.

Biology

Adult sunflower beetles are about 6–8 mm (1/4–3/8 in.) long. The head is reddish-brown and the shoulder is pale yellow with a reddish-brown patch at the base. Each wing-cover has 3 dark-brown stripes that extend the length of the back. The fourth stripe ends at the middle of the wing in a small dot that resembles an exclamation point.

They overwinter as adults in the soil. Usually, their emergence from the

soil in the spring coincides with the time that sunflower seedlings begin to appear in late May. The beetles feed throughout the day on the emerging seedlings.

Eggs hatch about a week after they are laid and the young larvae feed on the leaves at night. They hide among the bracts of the flower bud and in the axils of the leaves during the day. The larvae feed for about 2 weeks but, because of the long egg laying period, larvae may be present in the field for about 6 weeks.

The mature larvae drop to the ground, enter the soil, and pupate in earthen cells. The pupal stage lasts about 2 weeks. Adults of the new generation emerge and feed for a short period in late August and early September. They feed on the uppermost leaves or bracts of the plant before re-entering the soil to overwinter.

Scouting Techniques

Noticeable damage is often first seen on plants near the margins of sunflower fields. Both the larvae and adults are easily seen and counted on seedlings and young plants.

Monitor in at least 2 locations on each side of a field with 1 or 2 sampling sites near the centre. Twenty plants should be examined at each sampling site.

Economic Thresholds

The threshold is 1 adult beetle per 2–3 seedlings at the 2–6 leaf stage or more than 10 larvae per plant during the summer. Severe leaf damage may occur to plants in the 2 to 6 leaf stage when adult beetles are numerous.

Control may be necessary if defoliation caused by either the adults or the larvae reaches 25–30%, especially if more defoliation is expected.

If the majority of the larvae have reached maturity at about 25% defoliation, control should not be necessary.

Control Tips

In those years when adult control is necessary, larval control will also usually be required. One application of insecticide after all the eggs have hatched should provide good larval control.

Sunflower Midge

Midge larvae can affect the growth of sunflower heads. Heavily-damaged heads are gnarled and cupped inwardly, producing few seeds.

Host Crops

Sunflowers

Biology

The tiny, tan-coloured, adult midge is only about 2 mm (1/8 in.) long. Eggs are laid individually or in groups in depressions between the bracts of the sunflower bud. The featureless midge larva is tiny, being only about 3 mm (1/8 in.) long when full-grown. The newly-emerged larvae move to the bases of developing seeds or bracts. They use their rasping mouth-parts to feed on the plant tissues in these locations.

Mature larvae drop from the head and burrow into the soil. If conditions are favourable, they pupate and emerge the same season. Otherwise, they remain in the soil and overwin-

ter as larvae in cocoons or, in some cases, as pupae. Usually, the larvae pupate in the spring. The adults start to emerge in late-June. The adult midges only live for 2–3 days and are difficult to find in the field.

Scouting Techniques

Although damage may be severe, it is usually sporadic and localized. Damage to heads is usually restricted to field margins but, in severe infestations, damage is present throughout the field.

When monitoring sunflower heads, look for the midge larvae in the flower head, scarred bracts, and twisted or gnarled flowers. The larvae may be found at the base of the bracts or feeding in the flower, at the base of the florets. A 10x magnifier helps in locating the tiny larvae.

Economic Thresholds

No threshold has been established for this pest in either oil type or confection sunflowers.

Control Tips

Delayed planting (until late May) may avoid the first major emergence of the overwintering population. However, later infestations can still be severe.

Some commercial hybrids are tolerant or resistant to the sunflower midge. Consult your provincial agricultural representative for information on the most resistant varieties.

Insecticides do not work well against this pest. They provide inconsistent and inadequate control of the adults and larvae. Because the larvae crawl into the bud soon after hatching, they are protected from foliar applications. Insecticides can control the sunflower midge only if they are applied to the foliage just before the adults emerge. However, because this emergence cannot be accurately predicted, insecticide applications are ineffective.

Sunflower Seed Weevil

Larval feeding reduces seed weight and oil content. Because most seeds are only partially fed upon, it is difficult to separate healthy from weevil-damaged seed. This causes downgrading of confectionary sunflower seed.

Host Crops

Sunflowers

Biology

The red sunflower seed weevil is the most common of the 2 species that can occur in the Prairies. The adults are 2.5–3 mm (1/10 to 1/8 in.) long and are covered with reddish-orange, oval scales. The larvae occur in the upper third portion of developing sunflower seeds.

The adults appear during late June on volunteer sunflowers and feed on the bracts where they form pinpoint holes. As the bud develops and opens, adults move to the inflorescence and feed on pollen produced by the disk flowers. Females lay their eggs inside the seed coat of developing seeds. Populations are highest on plants at 50% anthesis. The egg laying pattern follows seed filling which progresses from the outside to the centre of the head. Usually, an infested seed contains a single larva. The larvae are small, cream-coloured, legless and C-shaped in appearance.

In late August, the mature larva chews an exit hole in the seed, drops to the ground directly beneath the sunflower head, and overwinters in the soil. Pupation occurs in the soil during early June through early July.

The gray sunflower seed weevil is not as common and is slightly larger (3–3.5 mm or 1/8 in. long) than the red seed weevil larvae. Seeds infested by this larvae enlarge, protruding above the surrounding seeds, and lack a kernel. The damage caused by a single larva of this species exceeds that of the red seed weevil because of the loss of the entire kernel. However, it usually does not cause economic damage to sunflowers used for oil because of its low population level and low reproductive rate.

Scouting Techniques

Begin scouting for seed weevils as soon as the yellow ray petals are beginning to show. Counts should continue until the economic threshold level has been reached or most plants have reached 70% pollen shed at which time very few seeds are suitable for egg laying.

When sampling, follow an X or Z pattern in the field. Begin counting at least 30 metres (100 ft.) into the field to avoid field margin effects. Counts taken along the field margin will lead to abnormally high weevil counts that will not be representative of the field. Count the number of weevils on 5 plants at each site for a total of 25 plants.

For accurate checking of individual sunflower heads, brush the face of the heads vigorously in order to bring the weevils to the surface or spray mosquito repellent on the head. This will force the weevils to move out of their hiding spots.

Economic Thresholds

In sunflowers grown for oil, the threshold is 10–12 weevils per plant. In sunflowers grown for confection, the threshold is 1–2 weevils per plant.

Control Tips

Insecticides, sometimes in combination with trap-cropping, remain the major management tool to reduce damage. Determine the sunflower plant growth stage before applying an insecticide. The weevil does not begin to lay its eggs on sunflower heads before heads reach 40% bloom (the outer 40% of the florets have opened).

If treatment is necessary, insecticides should be applied before 3 out of 10 plants reach 40% bloom. Remember that 40% bloom does not mean that 40% of the plants in the field are blooming. To minimize harm to bees, insecticide applications should be done in the late evening or early morning. Check fields in 2–3 days to determine control levels.

Early planting helps to reduce seed damage because early planted sunflowers complete anthesis and are no longer susceptible to egg laying at the time of peak weevil populations. Fall or spring discing can reduce adult emergence.

Natural enemies of larvae in the seed include several species of parasitic wasps and flies and a fungus found in the soil.

Wheat Stem Maggot

Damage by this pest can be severe in some years. Heavy infestations of wheat stands may kill a significant portion of the tillers.

Host Crops

Wheat, rye, barley, oats, bluegrass, millet, timothy, and a range of other native and introduced grass species.

Biology

The adult fly is a small (about 5 mm or 1/4 in. long), yellowish-white fly, with bright-green eyes and 3 black stripes across the thorax and abdomen. The larva is as drab as the adult is colourful. Mature larvae are slender, about 6–7 mm (1/4 in.) in length, and pale-green or cream coloured. They look like a fly maggot and are usually found inside the stem.

In cereal plants or grasses, wheat stem maggot larvae overwinter in the lower parts of the stems. The larvae pupate in the spring and the adults emerge in June. After mating, the female flies lay small, white eggs, one per stem,

near the sheath of the flag leaf, over a period of 2–3 weeks. These eggs hatch into green-coloured maggots in about 5 days.

The larvae burrow into and consume the interior of the stem, killing the upper part of the stem and the head. They complete their larval development in 18–21 days. There are normally 2 generations per summer.

Scouting Techniques

When young tillers are attacked in the fall or early spring, the tillers usually die. The infested plants show the "white head" or "silver top" condition, typically produced by stem-boring insects. The symptoms usually show up in mid-to late June.

The damage is fairly distinctive — white heads without kernels on a plant that is still green. Typically, only 1–5% of the heads are affected and they are usually scattered randomly throughout the field.

The head will pull out with a gentle tug, and usually there is evidence of insect damage (chewing) on the stem above the top node.

Note that root rot infections may produce white heads. However, with root rot, the entire plant turns white. High temperatures and drought stress may also cause prematurely-whitened heads and the death of some spikelets.

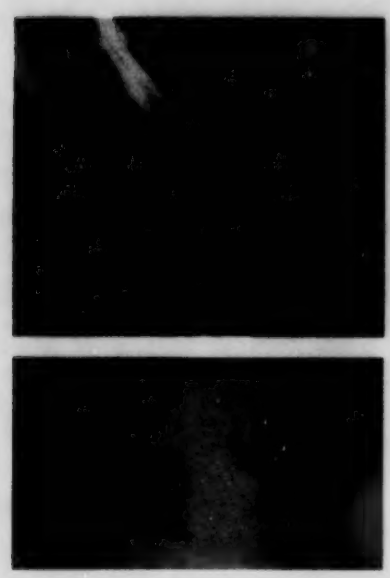
Economic Thresholds

No thresholds have been developed for this pest.

Control Tips

Cultural practices like crop rotation and stubble cultivation help to prevent the buildup of populations, especially if done throughout a region. The use of delayed planting is an effective management practice. Destruction of volunteer plants and infested straw is also recommended. There are no resistant varieties for this pest.

Orange Blossom Wheat Midge



Lauxanid fly, left and Wheat midge, right

Larval feeding will cause the kernels to shrivel. Kernels may be aborted entirely, not fully develop, or only be slightly damaged. As feeding increases, yield and quality are reduced.

Host Crops

This midge seems to prefer wheat. Other grasses (e.g., barley, rye, wheat grass, quackgrass) are rarely attacked.

Biology

The female midge is a tiny, fragile fly about 3 mm (1/8 in.) long with an orange abdomen. The tiny, orange-coloured eggs are barely visible to the human eye. The mature larvae are oval-shaped and are orange-red in colour. The pupae are brown and oval-shaped. They are found in the soil, in cocoons smaller than canola seeds.

Adult midge emerge from the pupal stage in the soil over a 5–6 week period, from mid-June to mid-July. This is about the time when the wheat heads are emerging from the sheath and beginning to flower.

During the day, the midge remain within the humid crop canopy. During warm, calm evenings, the female midge lay their eggs on the wheat kernels just prior to or at anthesis.

The young larvae move to the surface of the developing kernels and feed for 2–3 weeks. The mature larvae remain in the wheat head, each larva enclosed in a transparent skin, until activated by rain or damp weather conditions. Then, these larvae leave the head, drop to the soil surface, and burrow down into the soil (up to 10 cm or 4 in. down) to form overwintering cocoons. The following spring, the larvae pupate near the surface. The adult midge emerge from the pupae about 2 weeks later, completing the cycle.

Scouting Techniques

Damage will only be evident when the wheat kernels are separated and the developing seed is inspected. The seed is either undeveloped, shrivelled, or deformed. Close inspection with a hand-lens and penknife may reveal the tiny orange larvae feeding on the surface of a single seed.

On warm (15° C), calm evenings, the midge can be observed in the field, laying their eggs on the wheat heads.

Midge populations can be estimated by counting the number of adults present on 4 or 5 wheat heads. Inspect the field daily in at least 3 or 4 locations during the evening.

Economic Thresholds

If 1 or more adult midge are observed for every 4–5 heads, insecticide treatment is recommended. If wheat prices are high, treatment may be justified if there is 1 adult midge per 7–8 wheat heads.

Control Tips

Crop rotation will prevent a population build-up of wheat midge. Because barley and winter wheat are not as severely damaged as spring wheat, these crops may be grown in areas where infestations are low.

Early seeding is recommended to enable the crop to develop beyond the susceptible stage, before the midge emerge and begin egg laying.

Farming practices which promote greater crop uniformity, during heading and flowering (e.g., uniform seeding depth, higher seed rates to reduce tillering), will reduce midge kernel damage.

Fields should be treated within 4 days of reaching the threshold or immediately, if 50 percent of wheat heads are flowering. Insecticides applied after about 75% flowering do not provide adequate control and kill the parasitic wasps.

Insecticide treatments should be made in the late afternoon or evening when temperatures exceed 15° C and when the wind speed is less than 10 km/h.

Thorough coverage of the wheat heads is essential. Application methods which improve the uniformity and amount of spray deposited on wheat heads provide better kernel protection and subsequent grade or yield improvements. If adult midge activity persists for 3–7 days after the treatment, another application may be required.

Wheat Stem Sawfly

Found in wheat-growing areas throughout the brown soil zone of the Prairies, this pest can be very destructive. Larval feeding within the stem causes lodging and reduces the number of kernels and kernel weight.

Host Crops

Native grasses, wheat, rye, triticale and some varieties of barley.

Biology

The adult sawfly is wasp-like, slender, and about 8–13 mm (3/8–1/2 in.) long. The body colour is shiny-black, with 3 yellow bands on the abdomen. The mature larvae are dull-white, about 13–14 mm (1/2 in.) long, and have a well-defined, brown head. The tail end is covered with stiff bristles. The larva will assume an S-shape when extracted from the stem.

Wheat stem sawflies have one generation per year. The adult emerges in June and can usually be found in wheat fields until mid-July. The adults are very poor flyers and usually do not migrate very far from where they emerged.

The females will not lay eggs in a stem that has already reached the boot stage. The eggs will hatch in 5–8 days. The larvae spend all their time within the stem, feeding for about 30 days. The larva feeds upward through the nodes until the plant starts senescence. Light filtering through the dying stem stimulates the larva to move downward within the stem. Upon reaching a point in the stem at about 2.5 cm (1 in.) above the soil, the larva cuts a V-shaped notch completely around the inside of the stem.

After girdling the stem, the larva plugs the stem immediately below the notch with frass and plant material. After girdling and plugging the stem, the larva continues moving downward within the stem to below the soil line where it will overwinter. The larva then spins a cellophane-like cocoon. The cocoon provides protection from extreme drought and moisture. The

pupal stage begins in mid- to late May and lasts about 10 days. To escape from the plugged stub, the adult chews through the stem plug.

Scouting Techniques

Scout prior to harvest. Stems that contain a sawfly larva usually develop a reddish brown band below the second or third node. Determine percentage of plants cut by sawfly larvae per square metre.

Use a sweep net to sample for wheat stem sawfly. When sweep net samples average 2 female sawflies per 10 sweeps, you can expect about 12% cut stems; 4 females per 10 sweeps cause about 23% cut stems.

If sweep net samples are taken, determine the percent of females found. Remember the female sawfly will have a distinct ovipositor used for inserting the eggs into the stem. Males emerge first; females emerge later.

Economic Thresholds

Control methods are required if 10–15% of the crop in the previous year was cut by the sawfly.

Control Tips

Solid-stem wheat varieties are resistant to larval damage. Durum wheats are semi-solid and are rarely attacked by the sawfly. Another method of reducing sawfly populations is to plant an alternate crop that is not susceptible to sawfly infestation.

Shallow, fall tillage can result in 90% sawfly mortality. Spring tillage only provides about 25% sawfly mortality. In minimum till systems, the emphasis should be on host plant resistance, delayed planting of susceptible varieties, and rotations that include non-susceptible crops.

Mowing or grazing of field borders or ditch banks containing native grasses should be avoided because of the possibility of reducing the parasite populations in these areas.

Burning infested stubble may reduce sawfly numbers but it also greatly reduces parasite numbers and the benefits of returning stubble to the soil.

No insecticides are effective for sawfly control.

Wireworms

Wireworm larvae feed on germinating seeds or young seedlings. Stems of young seedlings are shredded, usually causing the central leaves to die. Damaged plants soon wilt and die, resulting in thin stands.

Host Crops

Wireworms prefer grasses but often attack corn, carrots, potatoes, wheat, barley, sugar beets, lettuce, and onions. Strawberries are also attacked.

Biology

Wireworms are slender, jointed, and hard-bodied. They have 3 pairs of legs behind the head, and the last abdominal segment is flattened with a keyhole-shaped notch. Full-grown larvae may reach a length of 1–4 cm (0.4–1.5 in.).

Adult beetles emerge from the soil in the spring. From late May through June, the female beetles lay 200–1400 eggs in loose or cracked soil and under lumps of soil. The young wireworms hatch and begin feeding on roots or germinating seeds.

The larval stage lasts anywhere from 1–5 years, depending on the species involved. When full grown, usually in July, the larvae pupate in the soil. The adults do not emerge until the following spring.

Scouting Techniques

Soil samples can be sieved to find any wireworms present in the field. Samples can be collected using a post-hole auger and a series of soil sifting screens or by marking out areas 50 cm x 50 cm (20 in. x 20 in.) and sieving the soil to a depth of 15 cm (6 in.). Repeat in different areas of the field to determine an average number of larvae per square metre (sq. yd.).

Sometimes, wireworm damage is confused with cutworm damage. Remember that, with wireworms, the plant is wilted and discoloured but remains attached to the root. With cutworms, the plants are usually cut off completely at or near the soil surface.

Economic Thresholds

An action threshold of about 32 wireworms per square metre (sq. yd.) is often recommended. If wireworms are found at this or a higher density, seed treatment is usually warranted in following years.

Control Tips

Some agronomists recommend that growers treat seed for 2 consecutive years after breaking sod to reduce the problem to a non-economical level. This should be done only if the risk of an infestation is high.

If wireworms are found in an emerging crop, there is no 'quick fix'. Often, the damage occurs or is seen too late to reseed the damaged patch. Also, the loss in yield does not justify the cost of re-seeding. The best plan is to consider what action may be necessary for the following year.

Scouting for Diseases

Diseases vary in intensity and severity each year depending on the weather, cultural practices, variety of crop grown, and the presence of a disease-causing agent. Efficient disease management requires that growers anticipate disease problems well in advance. For example, planting disease-resistant varieties will minimize disease problems. Proper crop rotations will also reduce the likelihood of disease occurrence in the future.

Scouting provides the information on diseases present, severity of diseases, and potential crop loss if untreated. Scouting of fields for disease should be undertaken weekly from crop emergence until maturity. The information gathered can be used to justify the use of fungicide application for disease control. It will also prevent the unnecessary use and expense of fungicide application or ensure that a fungicide application is made when it will provide the greatest economic return. Growers should have an organized method of scouting fields and should take the time to learn how to identify disease problems correctly. Fields should be monitored throughout the season to detect any developing problems. Learning about weather conditions that favour diseases will help growers know when to scout fields or to apply fungicides.

To justify disease control measures, identify any diseases present and determine the severity of each. Your agricultural representatives can provide further information on disease identification, scouting techniques, and a list of resistant varieties suited for your production area.

Following crop emergence, fields should be scouted for diseases every week. Take care to identify the disease correctly so that the proper fungicide can be selected.

To scout fields for disease:

1 Review the field history. Identify any fields that have had chronic disease problems. Ensure that you check for these diseases when scouting.

2 Scout weekly. Check the most disease-prone locations first. Foliar diseases tend to be worse in thick growth. Row ends, where seeding and fertilizer rates are inadvertently high, often have the heaviest disease pressure. Soil-borne viruses often occur in low, wet areas.

3 Scouting requires examination of 5–10 randomly selected sites that represent the character of plants within the field. Closely examine the leaves of each of the plants selected. The use of a magnifying glass or hand lens may be particularly useful, especially when first beginning to scout.

4 Identify all diseases present as soon as possible. Some diseases increase quickly (i.e., rust) and must be dealt with promptly. Multiple diseases sometimes require different control measures.

5 Map the areas where diseased plants are found to determine where treatments should be applied, to monitor any disease increase, and to assist in planning future crop rotations.

If you are not sure you have properly identified a disease, collect 1 or 2 plants (roots, plant, and soil) and take them to your provincial agricultural representative or an agronomist. Map any area of the field where the disease was found and make a point to check it again on your next visit.

Keep good records. About one week before harvest, a disease map should be drawn. Draw an outline of the field and circle the trouble spots you have identified. Be sure to label what disease was found in that spot and percent infestation found. Do not try to identify each specific spot you observed but the general area of the field in which you found the disease. This map will help if the same crop is grown in this field again.

The common crop diseases are described on the following pages and are grouped by crop affected.

Bacterial Blight (halo blight and common blight)

Halo blight and common blight reduce dry bean yields by reducing the ability of leaves to photosynthesize.

Host Crops

Dry beans

Biology

Hail, blowing sand, or wind-whipping, followed by rain, often trigger bacterial blights. Bacterial blights are also spread if bean rows are cultivated while leaves are wet. The most common bacterial diseases are halo blight and common blight.

Halo blight may occur any time during the cropping season. Typical symptoms are small brown spots that are surrounded by a light-green or yellow halo. The halo ranges from dime-size to the size of a quarter. It is caused by a toxin produced by the halo blight bacterium when the temperatures are less than 21° C (70° F) for at least part of the day. In hot weather, halo blight will resemble bacterial brown spot.

Both diseases are carried on the seed and can be spread from plant to plant by rain, hail, irrigation, or wind. In the soil, blight can survive in old, diseased plants for a year or longer.

Symptoms of Damage

Common blight and halo blight cause water-soaked, greasy looking spots on pods and dead spots surrounded by a chlorotic halo on leaves. The dead areas enlarge rapidly under favourable conditions until they cover most of the leaf, giving the plants a burned appearance. Pod lesions may appear as small, brown, scabby spots.

Scouting Techniques

A laboratory culture may be required to confirm field identification of a bacterial disease and to distinguish between the bacterial blights. Look for water-soaked spots on the leaves. The areas surrounding the spots may be yellowish, brown and brittle.

The pods may have small watery spots or large, irregular blotches. Late in the season, the blotches turn brown and become sunken and dry.

Economic Thresholds

None available.

Control Tips

Plant disease-free seed. This is important because all outbreaks of the disease have resulted from planting infected seed.

Use a 2 to 3-year crop rotation to avoid the chance of contaminating the newly planted crop.

Plow under plant debris as soon as possible after harvest to allow enough time for the debris to disintegrate over the winter. Avoid over-irrigation.

Do not work in infested fields that are wet with rain or irrigation water

Seed treatment helps prevent seed rot and damping off but will not control blight because the blight organism is often within the seed. Copper fungicides slow down the spread of halo blight but they are only moderately effective. They must be applied early in the season and repeatedly to provide control. Fungicide applications made after the disease develops are usually ineffective.

Leaf Rust

Most of the commonly grown dry bean cultivars are susceptible to one or more races of the rust fungus.

Host Crops

Dry beans. Pinto beans are more susceptible to rust than navy or coloured beans.

Biology

Symptoms first appear as white, slightly raised spots on the lower surfaces of leaves. Small red blisters are then formed on leaves, stems and pods. The lower leaves are the most severely infected. Heavy leaf loss is common. Occasionally, rust will appear on pods but rust on bean stems is rare. The disease is spread by wind, people, and implements.

Symptoms of Damage

Disease symptoms are typically circular, reddish-dusty spots on the lower leaf surfaces. As the season progresses, the spots may turn from red to black. Rust is most common on mature plants in the fall.

Scouting Techniques

Monitor bean fields early in the season. Look for small, red to reddish-brown pustules on the undersides of the leaves which rub off when touched. Timing of fungicide applications will be critical. Rust infections need to be caught early. A fungicide is needed if there are about two rust pustules per leaf and if the beans in the pod still have not developed to full size. If rust is severe in other fields within several miles, fungicides should be applied to fields of susceptible varieties, even if no rust has been found in the field.

Control Tips

Prompt crop destruction after harvest is very important in the control of rust. If this not done, rust can continue to develop and serve as a major source of inoculum. Brown clouds of rust spores have been observed above abandoned fields, carried by gusts of wind. Such inoculum loads can make it difficult to control rust, even with an intensive fungicide program.

Currently, the most important method for rust control is the periodic application of protectant fungicides. Aircraft or ground equipment may be used, but the latter is much preferred because of superior coverage of the underside of leaves and better penetration of the fungicide into the plant canopy. Initiate the fungicide program prior to the first sign of rust if rust is an annual problem. Where rust is sporadic in occurrence, begin the fungicide program at first sign of the disease. Subsequent applications may be required at 5 to 7 day intervals.

Growers should not plant beans back into the same field the following year because the rust inoculum survives on crop residue. Burning residue and crop rotation will reduce the amount of inoculum. Planting a resistant variety reduces the need for a fungicide program.

White Mould (Sclerotinia)

If white mould is severe, bean yields may be reduced by 225–550 kg/ha (200–500 lbs./ac.).

Host Crops

Dry beans, field peas, canola, sunflowers, lentils, mustard, potatoes.

Biology

The fungus overwinters as hard black bodies or sclerotia in crop debris and in the soil. The disease cycle begins with the germination of the sclerotia to produce small, mushroom-like structures. Warm (15–25° C or 60–75° F), wet weather, 1–2 weeks before flowering, coupled with a thick bean canopy, favour this development.

Once these mushrooms have matured, each of them can release up to 2 million spores over a 5–10 day period. These spores germinate and infect bean plants, aided by a dead food source (usually the bean blossoms). The disease develops most rapidly at temperatures of 20–25° C (68–77° F). The fungus can spread from the dead blossoms to adjacent flowers, stems, leaves, and pods within 2–3 days. The sclerotia formed may persist in the harvested pods and seed, fall to the soil, or remain in the crop residue.

Symptoms of Damage

The disease affects the stems, leaves, pods, and seeds of beans. The first symptoms are brown, water-soaked lesions that enlarge rapidly under cool, moist conditions. These lesions become watery, rotted sections of plant tissue. The lesions rapidly increase in size. Under humid conditions, such lesions may become covered with white, cottony growth. Within a week, black sclerotia are formed in the infected tissue. The lesions eventually become dry, bleached, and shredded. Wilt and subsequent death of entire branches and main stems may result when the fungus girdles the tissue.

Scouting Techniques

If the field has a previous history of sclerotinia and the weather has been wet for two weeks prior to flowering, check the field for small mushrooms just before and during the early blossom stage. Look for soft, watery lesions that become covered with dense, white, cottony growth.

Economic Thresholds

White mould can affect both the yield and quality of the seed. The affected seed may be discoloured and lighter in weight than healthy seed. Plants not protected by a fungicide may yield up to 23% less than protected plants. White mould also leads to increased levels of sclerotia in the soil. Affected fields may have to be taken out of bean production for several years.

Control Tips

Plant varieties that do not produce a heavy vine. Provide adequate aeration between rows and within rows by decreasing the seeding rate or increasing the plant spacing.

Dry beans should not be planted more than once every 4 years. Avoid rotations with other crops that are highly susceptible to white mould, such as sunflower and canola.

A fungicide application is warranted if a dry bean field has a yield potential of 2250 kg/ha (2000 lbs./ac.) or more, white mould is a common problem in the area, and weather has been wet for 1–2 weeks before flowering. The fungicide treatment must provide good coverage of the entire plant, particularly the blossoms. Fungicides are much more effective in preventing white mould infection than they are at curing the infection.

Do not over-irrigate. After the pods have started to form, allow the soil surface to dry out before re-irrigating.

Excessive applications of nitrogen should be avoided because they favour heavy vine growth.

Blackleg

Blackleg is becoming an increasing problem in the Prairies. There is a mild and an aggressive strain. The aggressive strain is now widespread. Losses of over 50% have been recorded in some fields where susceptible varieties of canola were grown.

Host Crops

Canola and rapeseed. Wild mustard is also an important host. Blackleg is not a problem in the highly-resistant mustards (yellow, brown and oriental).

Biology

Blackleg overwinters on infected canola stubble and can survive for at least 2 years. The blackleg fungus may also occur at low levels in the seed. Seed infection is seldom more than 1–2%. However, this amount can introduce the fungus into new areas. The fungus is spread by rain-splashed spores, windborne spores, and by infected seed.

Leaf spots can occur from the seedling stage to maturity. Whitish, round to irregular spots dotted with numerous black fruiting bodies appear on the leaves and stem in the summer. Later in the season, superficial lesions may occur at the stem base. The lesions are coloured white to grey (mild strain) or brown to greyish black (aggressive strain). The brown to greyish black stem lesions become sunken, girdling the stem near the soil line and cause premature death.

Symptoms of Damage

In the summer, the symptoms are buff-coloured, round to irregular spots with black fruiting bodies. Stem lesions later in the season cause premature plant death.

Do not confuse with premature ripening caused by sclerotinia. Blackleg does not have sclerotia bodies in the canola stems.

Scouting Techniques

When blackleg spores come in contact with growing canola, they infect the living cells of the plant. Both types of blackleg cause dead patches that appear as pepper-like spots on canola leaves, pods and stems. The aggressive strain infects canola from germination to maturity, while the mild strain is only really active on the ripening crop. Inspect lower leaves for spotting. Check patches in the field where the plants have died prematurely. To distinguish from sclerotinia, look for sclerotia bodies in the stem.

Economic Thresholds

None available.

Control Tips

Disease prevention is important. Use disease-free seed. Seed from diseased areas should be treated with a seed treatment containing a fungicide.

Resistant varieties of canola are available. The use of moderately susceptible or moderately resistant varieties may give low levels of blackleg. However, the use of susceptible varieties will likely give high levels of blackleg. Most new Argentine canola varieties are moderately resistant or resistant.

All Polish varieties are susceptible. Check your provincial seed guide for a listing of the varieties available and their susceptibility to blackleg.

Incorporate infected stubble after harvest. Blackleg survives in slowly decomposing canola stubble. A 4-year rotation between canola crops is recommended once blackleg has been detected in a field. Control volunteer canola and wild mustard in other crops.

Black Spot

Black spot is common at low levels but is usually not a serious disease. However in some years it can cause severe losses over 20% due to shrunken seeds or premature pod splitting.

Host Crops

Canola and mustard

Biology

Black spot overwinters on infected crop residue and seeds. In the spring, the spores germinate, penetrate plant

tissue, and cause lesions, usually within a few days. Warm, humid conditions favour the disease. The lesions develop and produce wind-borne spores which may cause more infection on neighbouring canola or mustard. The cycle continues throughout the season. Lesions on the pods may infect seeds.

Symptoms of Damage

Small, round spots on the pods and stems, that are initially brown to black, become black to grey, with a black border. Severe leaf spotting causes the leaves to die and drop off. Infected pods become dry and shrunken and split prematurely.

Scouting Techniques

Look for small, round, brown to black spots on the stems and pods.

Economic Thresholds

None available.

Control Tips

Use disease-free seed and a seed treatment. Follow a 3-year crop rotation with any crop except canola or mustard.

Early swathing of an infected crop may prevent serious shrinkage or shattering losses.

Yellow, brown and oriental mustard and Argentine canola are more resistant than Polish canola.

Control volunteer canola and cruciferous weeds like wild mustard in subsequent years to reduce inoculum levels.

Sclerotinia

Sclerotinia stem rot is the most serious disease of canola in the Prairies. Losses ranging from 5–100% have been reported for individual fields. On average, yield losses equal 0.4 to 0.5 times the percentage infection.

Host Crops

Canola, sunflowers, dry beans, field peas, lentils, mustard, potatoes

Biology

The severity of sclerotinia in canola is variable. It is dependent on the time of infection and climatic conditions. The disease is favoured by cool temperatures and prolonged periods of precipitation.

Sclerotinia survives in the soil for up to 4 years as irregular-shaped fungal bodies, called sclerotia. The sclerotia germinate in the summer, producing mushroom-like structures. These release wind-borne spores that travel up to 1 km. The disease is favoured by moist soil conditions (at least 10 days at or near field capacity) and temperatures of 15–25° C (60–75° F), prior to and during canola flowering. The spores cannot infect leaves and stems directly. They must first land on flowers, fallen petals, and pollen on the stems and leaves. These provide the food necessary for the spores to germinate, grow, and infect the canola plant.

The symptoms usually develop several weeks after flowering begins. The plants develop pale-grey to white lesions, at or above the soil line and on upper branch-

es and pods. The infections often develop where the leaf and the stem join because the infected petals lodge there. Infected stems appear bleached and tend to shred. Hard black fungal bodies, of varying sizes, develop within the infected stems, branches, or pods. Plants with girdled stems wilt and ripen prematurely.

Symptoms of Damage

The symptoms include premature ripening and pale-grey or white lesions on stems, branches and pods. Sclerotia form within the stems, branches and pods. Severely infected crops frequently lodge, shatter at swathing, and make swathing more time consuming.

Scouting Techniques

If the field has a previous history of sclerotinia and weather conditions have been wet several weeks prior to canola flowering, scout the field for small mushrooms at the early blossom stage. After flowering look for prematurely-ripened plants. Infections begin as a soft rot that girdles the stem. The lesions turn white, become brittle, and tend to shred.

Economic Thresholds

Petal test kits and in-field diagnostic kits are commercially available. These enable a grower to determine the cost effectiveness of sclerotinia control. A sclerotinia stem rot checklist can also assist in predicting stem rot disease levels. The checklist considers yield potential, previous disease presence and current weather conditions. Ask your agricultural representative for a copy of the checklist. The checklist will provide some direction in making a decision on whether or not to use a fungicide.

Control Tips

All canola varieties are susceptible to sclerotinia. Polish varieties have lighter canopies and seem to have much lower infection levels. Use seed that is free from sclerotia.

A minimum of a 4-year rotation between susceptible crops is recommended. Sclerotinia also attacks pulse crops, sunflowers, mustard, sweet clover, and potatoes. This limits the crops that can be used in a rotation to manage the disease.

Fungicide must be applied before symptoms of stem rot are visible, at the 20–30% bloom stage of the crop. To check bloom stage, sample several plants over the field and assess the number of open flowers. Find the main stem, pull off the secondary branches, and count only the open flowers on the main stem. It usually takes a crop 2–4 days to go from first flower to 10% bloom. At 30% bloom, a field is said to be fully flowered, with the maximum number of flowers open at one time. Do not apply fungicide if the stem rot infection is already evident since it is too late to have any effect. Check the provincial Guide To Crop Protection *for guidelines on the timing of fungicide applications.*

Bacterial Blight

Bacterial blight infestations only occur after prolonged periods of wet weather. They are usually localized within the field and therefore do not usually cause widespread damage.

Host Crops

Wheat, oats, barley

Biology

This disease is caused by a common bacterium that persists in soil and water and is spread by wind-driven rains. The bacteria overwinters on crop residue, seed, fall-sown cereals, and perennial grasses. Spring infection may result from any of these sources. Subsequent infections are spread by

splashing rain drops, plant to plant contact and insects.

Bacterial blight develops on the upper leaves of wheat during periods of cool, wet weather, after the plants have reached the boot stage. Leaf blight is associated with high relative humidity, wet weather, and cool spring temperatures (15–25° C or 60–75° F). Warm, dry weather stops the disease and new emerging leaves may be relatively free of bacterial infection.

Symptoms of Damage

The initial lesions appear as small water-soaked spots. The lesions expand and then appear as dry dead tissue bracket. The spots often join within a few days to form large blotches. The entire surface area of an infected leaf may be affected. During wet periods, bacterial ooze may develop within the lesions. The head does not usually develop symptoms.

Scouting Techniques

Look for lesions that progress from grey-green to tan-white and join to form irregular streaks or blotches. Entire leaves may become bracket.

Economic Thresholds

None available.

Control Tips

Avoid infesting clean fields by following good production practices. Use seed from crops that are free of bacterial disease. Use a crop rotation of three or four years.

Mow infected wild grass along headlands before sowing winter rye. No chemical controls exist.

Barley Yellow Dwarf Virus

Plants infected at an early growth stage (before the 4 to 5-leaf stage) may be severely stunted and may not head. Plants infected after the boot stage show few or no symptoms and may not suffer any yield losses.

Host Crops

Wheat, barley, oats and other grasses

Biology

Aphids acquire the virus by feeding on infected plants and spread the virus when they feed on healthy plants. Overwintering of the virus occurs in the southern USA. Aphids carrying the virus are moved north by air currents. The virus is not transmitted by seed or soil. The build-up of aphid populations and extensive spread of this virus disease is favoured by winds from the

south and by cool, moist summers (which also favour wheat and grasses). Infections can occur throughout the season and are most abundant when there are high populations of aphids present. The leaf discolouration symptoms that indicate viral infection develop within about 2 weeks of inoculation at temperatures between 18–21° C (65–70° F). When infections occur at temperatures above 30° C (85° F), the symptoms do not develop.

Symptoms of Damage

Leaf discolouration appears as shades of yellow, red or purple from tip to base and from margin to midrib. Look for yellowed or reddened flag leaves. Infected plants may be stunted and scattered among healthy plants. Note that these symptoms are sometimes confused with nutritional disorders. Yellowing can be confused with nitrogen deficiency.

Scouting Techniques

Look for stunted plants and leaves that have turned golden yellow from the tips downward.

Economic Thresholds

None available.

Control Tips

Planting date affects the severity of the disease and yield loss. Early planted winter cereals and late planted spring cereals may be subject to high aphid populations at early growth stages, resulting in greater yield loss.

Oat varieties differ in their susceptibility to this disease but there is no effective resistance in any of the cereal crops.

Control volunteer wheat, barley and oats because they may serve as late season hosts to the aphids and virus.

Common Root Rot (Wheat, Barley, and Oats)

Common root rot is a serious disease of wheat, barley, and oats. Infected plants tend to produce fewer tillers with smaller and fewer seeds per head.

Host Crops

Wheat, barley, oats, rye and triticale

Biology

This disease is caused by a complex of soil-borne fungi. The spores germinate in the soil. Seedlings become infected following germination. Spores are produced on diseased tissue and are spread by wind, water, cultivation, and infected seeds. Further infections continue throughout the growing season with new spores being produced on plant parts as they mature.

Patchy emergence is usually the first indication that damage has occurred. Infections start on the roots and sub-crown internodes and move to the leaves. Seedlings may die before or soon after emergence even though they only show slight damage. Drought and warm weather cause more severe infections. Nutritional stress can also favour infection.

Secondary infections by other soil-borne pathogens may mask the initial symptoms. Common root rot is favoured by soil compaction that restricts root growth and by over-applications of nitrogen under moisture stress conditions. Plants stressed by Hessian flies *(page 24)* are also more vulnerable to infection by common root rot. Spores may remain viable in soil for several years.

Symptoms of Damage

Symptoms include damping off (sudden death) of emerging seedlings, stunted chlorotic growth, reduced root growth and decay of the crown area. Severe infections can abort tillers. A darkening or reddish-brown decay often occurs in the sub-crown internode between the crown and second or third node.

Scouting Techniques

Early detection is required for proper diagnosis. Pull up plants and examine the crowns and subcrown internodes for disease. Look for brown discolouration of stem bases, roots, crowns, and lower leaf sheaths. Infected plants are generally shorter and produce fewer stems and grains per head. At times, plants appear bleached and dead.

Economic Thresholds

None available.

Control Tips

Avoid soil compaction. Turning under stubble may help to reduce infection levels. Apply adequate nitrogen, phosphorus and potassium to encourage vigorous root and shoot growth to enable plants to resist or tolerate infection.

Under cooler temperatures, delayed seeding and proper seeding depths (3–4 cm or 1.25–1.5 in.) promote uniform germination and emergence to reduce infection. Avoid growing continuous wheat or continuous barley. Rotation with non-cereal crops and control of grassy weeds will reduce inoculum levels.

Commercial seed treatment fungicides that prevent seed decay also provide some protection against post-emergence infections.

Ergot (Wheat and Rye)

Ergot infects many cereals and grasses, including, in order of decreasing susceptibility, rye, triticale, wheat and barley. Oats are rarely affected. Yield reductions are usually less than 10%. However, the ergot bodies contain toxic alkaloids that are poisonous to humans and livestock.

Host Crops

Rye, triticale, wheat, barley

Biology

Ergot overwinters as black, grain-sized fungal bodies or sclerotia in the soil and in stored grain for about one year. In spring or early summer, the sclerotia germinate and produce tiny spores. They are carried by wind and infect open grain florets and immature seed. Infection of the cereal flowers may produce honeydew, a shiny, sticky liquid that oozes from infected florets and contains large numbers of ergot spores. The spores spread to adjacent flowers and heads by wind, insects, and rain splash. Sclerotia that germinate in June can infect early flowering weed grasses to produce honeydew when cereals are flowering. The florets are most susceptible to infection just before anthesis. Infected florets eventually develop dark, hard horn-like structures (sclerotia) instead of normal kernels.

Cool, damp weather in late spring and early summer favour ergot germination and prolong the flowering period of cereals and grasses increasing the opportunity for ergot infection.

Sclerotia return to the soil with the straw and chaff or with contaminated seed stocks. Ergot rarely survives for more than one year in the soil.

Symptoms of Damage

Conspicuous, purple to black fungal bodies are produced in place of kernels. They are persistent in threshed grain.

Scouting Techniques

Ergot is often found at the edges of fields, moving into the field from grassy margins. Individual heads may contain one or more ergot bodies. When the source is headland grass, the highest density of ergot is around the perimeter, along the headlands. If the infected plants are more evenly distributed throughout the field, the source is probably contaminated seed or a previously infected crop.

Earlier in the season, before the ergots are produced, an amber liquid or honeydew can be seen on individual flower heads. The heads collect dust and pollen on the sticky honeydew and appear dirty. Later in the season, ergot is easily recognized by the hard, black bodies that replace the grains of the affected florets.

Note that, when mature grain is exposed to strong winds, the protruding ergot bodies may be shaken off the head, reducing the amount of ergot in the harvested grain by up to 70%.

Economic Thresholds

Ergot causes losses through a reduction in yield and through rejection or downgrading of contaminated grain. Yields are occasionally reduced by as much as 5% in rye and 10% in wheat. Contamination in excess of 0.25% in wheat results in downgrading to "sample".

Control Tips

Delay swathing in headland areas to allow strong winds to shake out the ergots from standing grain. Harvest these swaths separately because they are likely to have the highest ergot contamination.

Use good sanitation. Cut or burn nearby grasses before they come into head. Clean seed to remove ergot bodies. If a few ergot bodies remain in the seed, plant at least 5 cm (2 in.) deep or store seed for one year to reduce the viability of ergot bodies to almost zero. Cultivate deeply after a crop has been infected with ergot to bury the sclerotia at least 2.5 cm (1 in.) below the soil line or rotate to a resistant crop. Do not sow wheat after rye.

Leave at least one year between susceptible crops, ie. rye, triticale, wheat and barley. Note that brome and couch grass are extremely susceptible to ergot.

There are no resistant varieties or effective fungicides. Test soils for copper availability. If copper levels are less than 1 ppm, it may be necessary to apply copper fertilizer to the soil to reduce or eliminate this disease in wheat and barley. With adequate soil copper, all cereals except rye will have little or no ergot infection.

Fusarium Head Blight (Wheat and Barley)

Fusarium head blight (or scab) can reduce yields in wheat from floret sterility and poor seed filling. Traces of the mould on the seeds results in down-grading. The fusarium mould can also produce toxins in wheat and barley that can be harmful to humans and livestock.

Host Crops

Wheat, barley, oats

Biology

Fusarium head blight overwinters in soil, grass and crop residue as well as in the seed. Seedlings may become infected at emergence. Spores are produced first on stem infections at the base of the plant. These spores are spread by rain or wind to infect flower parts, glumes or other portions of the

head. Infections are most frequent and severe at anthesis.

Head blight is recognized by premature bleaching of one or all of the spikelets in the head. The infected spikelets are often sterile. The seed in the spikelet stalk, above the point of infection, may not develop. Diseased heads have small dark spots and exhibit fungal growth with an orange to pinkish tinge. Infected grain is shrivelled and lighter in weight. Individual kernels are usually whitish in colour.

As warm, moist weather develops, spores that are spread by rain splash and wind infect the florets. Continuous moisture and warm weather (25–30° C or 77–86° F) are needed for infection when the grain is flowering.

Symptoms of Damage

Blight symptoms develop within 3 days after infection if environmental conditions are favourable. Infected heads ripen prematurely. If the stem of the seed head is infected, everything above that point will be white.

Scouting Techniques

Look for a ring of pink or salmon colour at the base of the florets. Only partially-filled seeds will be found in the infected spikelets. Shrivelled grains may appear tan to white, with traces of pink on the seeds.

Economic Thresholds

None available.

Control Tips

Although there are currently no resistant cultivars, this disease may be more severe on semi-dwarf and durum wheats than on hard red spring cultivars. Consult your provincial seed guide or agricultural representative on the best cultivars to use as there are differences between cultivars in their reaction to this disease. When harvesting, try to blow out fusarium damaged kernels since they are lighter than healthy seed.

Follow cereal crops with broad-leaved crops. Do not seed wheat into wheat, barley, or corn stubble or into fields that are near corn fields that were infected by fusarium fungi. Turn under crop residue to reduce inoculum levels. Control barnyard grass and quackgrass because these are alternate hosts.

Use clean seed that is free from fusarium infection. Fungicide seed treatments will protect the seedlings from seedling blight.

Leaf Rust (Wheat, Barley, and Oats)

Rust has the potential to be a serious threat to all small grains. Leaf rust can cause up to 25% yield loss under favourable conditions. Leaf rust in oats is commonly referred to as crown rust.

Host Crops

Wheat, barley and oats

Biology

Leaf rust overwinters in the southern USA and is blown into the southern Prairies by prevailing winds. It is recognized by its characteristic orange-red pustules that erupt from the upper surface of leaves. Rust spots are very small, circular or elongated, and are vivid orange red in colour. They may occur on stems but are most common on the upper surface of the leaves.

These pustules are approximately the size of a pin head and filled with thousands of orange-red spores that are wind-borne and can infect additional leaves and wheat plants. The spores often form the core of rain drops and initially infect and produce pustules where the raindrops have collected at leaf axils and tips.

When heavily infected, the whole leaf will die. Winds can carry rust spores for great distances. The disease can develop rapidly at temperatures between 11–22° C (52–72° F) when moisture is not a limiting factor.

Symptoms of Damage

Leaf rust pustules are dusty-yellow to bright-orange, small round to oval spots that are found on the leaves and sheaths. As the plant matures, the rust pustules darken and may appear black.

Scouting Techniques

Look for small, round, orange pustules on the leaves and leaf sheaths. As the plant matures, the pustules darken.

Economic Thresholds

In some states in the USA, fungicide application is recommended if there is an average of one leaf rust pustule per leaf. Spraying is recommended if the threshold is met in three of the five spots sampled in the field. Repeat scouting in about four days if the threshold is reached at one or two of the spots in the field. Spray decisions should involve scouting information as well as rainfall forecasts. Severe disease development will be favoured by heavy rainfall. If the weather is very dry, intervals between scouting can be extended.

Control Tips

Consult your provincial seed guide and seed resistant varieties if rust is a recurring disease. Early seeding may help reduce high infection levels. Use foliar applied fungicides.

Septoria Leaf and Glume Blotch

(Wheat, Barley, and Oats)

Septoria can infect all small grains. The symptoms may occur at any time during the growth of the plant and on any portion of the plant. There are 2 forms of septoria. One causes only leaf blotch; the other causes both leaf and glume blotch.

Host Crops

Wheat, barley, oats

Biology

Septoria leaf and glume blotch overwinter on seed or crop residue as well as on the leaves of winter wheat. The dark-coloured fruiting structures release spores in the form of droplets which are spread by rain. These spores cause spring infections. Late summer infections are caused by wind-blown spores. Wet windy weather favours disease outbreaks, while dry weather stops disease development.

The spores also infect and colonize stems and the wheat head. When the head is colonized the florets become streaked with a purple-brown colour and "dotted" with the minute black fruiting bodies. Within colonized florets, the grain fill is impaired and results in low test weight and shrivelled seeds.

The septoria leaf and glume blotch pathogen survives within infested straw, seed and on volunteer wheat and serves as the source of inoculum to start off the disease cycle in the new crop of wheat. The disease is favoured by splashing rain, high humidity, and temperatures between 20–28° C (68–82° F). The disease characteristically moves upward from infection initiated on the lower leaves within the crop canopy.

Symptoms of Damage

Symptoms first appear as small spots on the lower leaves of seedlings. These spots grow into larger, lens-shaped lesions which are initially yellow and later turn reddish brown. They become grey or greyish-brown and speckled as black tiny fruiting bodies develop. Septoria causes more or less linear or rectangular lesions. There may be dark sporulating structures in the lesions. Note that with tan spot *(page 78)* lesions are oval and tan.

On the chaff or glumes, brown marks start at the tips, develop downwards and later produce pepper-like black dots. Infection can also occur on the stems at the joints or nodes.

Scouting Techniques

Scout fields prior to flag leaf emergence.

Economic Thresholds

In some states in the USA, fungicide application is recommended if 25% of the leaves have one or more lesions. If the threshold is met in 3 of the 5 spots sampled in the field, spraying is recommended. If the threshold is met at 1 or 2 of the spots in the field, repeat scouting in about 4 days. You should consider rainfall forecasts as well as scouting information in your decision. Heavy rainfall favours the development of severe disease. Also, intervals between scouting can be longer if the weather is very dry.

Control Tips

Current varieties have limited resistance. Incorporate wheat straw by tillage in the fall or early spring in fields not prone to erosion.

Use a crop rotation that includes non-cereal crops for at least one year between successive wheat crops. Use lower seeding rates and use adequate rates of fertilizer.

For fungicide applications, weather should be conducive to the spread of disease. Yield potential should be high enough so that the increased yield will cover the fungicide and application costs.

Stem Rust (Wheat, Barley, and Oats)

Stem rust, one of the most destructive diseases of cereals, was responsible for millions of dollars of losses before the introduction of resistant varieties. Stem rust may become a severe problem on barley, as a new race of wheat stem rust (QCC) has been building up for several years and can attack currently recommended varieties of barley. All wheat varieties except winter wheat, have good resistance to QCC.

Host Crops

Different forms of stem rust attack different cereals and grasses. Wheat stem rust can attack wheat, durum wheat and barley (but not oats and rye). Stem rust of rye attacks rye, barley, and quackgrass (but not oats or wheat) but is seldom important on the Prairies. Stem rust of oats attacks only oats, wild oats and meadow fescue. Different strains of stem rust are referred to as races. Cereals and grasses differ in their ability to resist some races.

Biology

Stem rust spores overwinter in the southern USA. A wave of infection usually advances northward by wind-blown spores released from infected wheat or barley plants. Stem rust usually enters Manitoba from late June to mid-July depending on weather conditions and the extent of disease devel-

opment on barley crops in the central USA. The disease usually appears on plants in early summer.

After infection, pustules form in 7–10 days. The pustules break open, releasing masses of brown spores that can infect surrounding plants. Temperatures of 20–25° C (68–77° F) favour stem rust development. Rust spots are very small, circular or elongated, and vivid orange-red in colour. Later in the year, the rust pustules darken because of the production of dark-brown-black spores which are the overwintering stage of the rust.

Infected plants usually produce fewer tillers, set fewer seeds per head, and yield small shrivelled seeds with poor milling quality and food value.

Symptoms of Damage

Stem rust produces dusty, raised reddish-brown, oblong spots on leaves, stems and heads. These pustules become black as the plant matures.

Scouting Techniques

Look for reddish-brown, elongated spore pustules on the stems, leaves, glumes, awns and kernels. The red spore dust may stick to your hands, clothing, and machinery. Later in the season, the pustules produce black overwintering spores.

Economic Thresholds

None available.

Control Tips

Consult your provincial seed guide and if stem rust is a recurring problem, plant resistant wheat varieties. There are currently no barley varieties with resistance to QCC. Seed early maturing varieties. If necessary, apply a foliar fungicide at the very early stage of disease development.

Tan Spot (Wheat)

Tan spot affects wheat, brome, and wheat grasses. Rye and barley are rarely affected and oats are resistant. Severe infection by tan spot in the seedling stage can kill or severely weaken plants. Re-seeding may be required.

Host Crops

Wheat, wheat grasses, and brome grass

Biology

Tan spot overwinters on standing wheat stubble, straw on the soil surface or partly buried by tillage, and on bales of wheat straw. Spores are produced in the spring and are carried by wind to growing plants. At least 6 hours of wetness are required for infection. Temperatures, ranging between 15–28° C (60–82° F), and periods of dew favour infection. Spores produced on diseased leaves tend to spread during the growing season under periods of wet weather.

Tan spot develops on both upper and lower leaves. The lesions first appear as tan-brown flecks that expand into lens-shaped lesions, similar to the lesions produced by the septoria leaf blotch

fungus *(page 74)*. Tan spot lesions range in size from 6–12 mm (1/4–1/2 in.) in length and are surrounded by a chlorotic (or yellow) border. As a lesion matures, the centre becomes darker because of the production of air-borne olive-brown spores that can infect other leaves, stems and plants. The infested straw that remains after harvest serves as the source of inoculum for the next season's wheat crop.

Symptoms of Damage

Tan spot produces small tan-brown flecks on lower leaves which expand into lens-shaped brown blotches up to 12 mm (1/2 in.) long. These blotches often develop a small, dark-brown centre. Spots have yellow halos on leaves in June and early July. Large spots often coalesce when conditions are favourable for disease development. Heavily infected leaves may wither and die.

Scouting Techniques

Look for tan or brown flecks or yellow-rimmed blotches on the lower leaves. Later in the season, look for withered and dead leaves. Examine the heads for infected seed. Seeds infected with tan spot will usually appear smaller and shrivelled and may have a pinkish colouration.

Economic Thresholds

None available.

Control Tips

Current varieties have little resistance.

Crop rotation with barley and oats or non-host crops (e.g., canola, flax, corn, potatoes and alfalfa) will reduce disease carryover.

Use wide row spacing to reduce in-crop humidity. Use adequate but not excessive fertilization to limit the disease.

Turn under wheat residue to reduce the amount of surface straw that can produce air-borne spores during the growing season.

Yield increases up to 15% have been reported when a fungicide was applied.

Wheat Streak Mosaic

Infected wheat plants may die, fail to set seed, be stunted or be unaffected, depending on when they are infected. Damage usually ranges from noticeable yield reductions to crop failures.

Host Crops

Wheat streak mosaic virus attacks barley, corn and some grasses, but is most common on winter and spring wheat. Oats and rye may be infected but they do not appear to be seriously damaged. Wheat is the only cereal that is seriously affected.

Biology

Wheat streak mosaic is a viral disease of wheat. The virus enters the leaves and spreads to all parts of the plant. Infected plants are usually stunted and produce fewer seeds, which are often badly shrivelled. The earlier the infection, the greater the effect on the plant.

Wheat streak mosaic virus is transmitted by the wheat curl mite and by leaf rubbing. The mite can be blown from field to field by wind.

The mite and virus overwinter on winter wheat. In the spring, mites multiply rapidly and are blown to spring wheat or volunteer spring wheat. These hosts harbour the mite and virus over the summer. If winter wheat is sown near unharvested spring wheat, infected mites can be blown onto winter wheat completing the disease cycle.

Development of this disease depends on the population of mites, the presence of virus-infected wheat plants, and sufficient moisture for good plant growth and rapid mite reproduction. Severe outbreaks occur when there is a build-up of mites and virus on volunteer spring wheat in fields next to winter wheat that was planted early.

Symptoms of the disease become more pronounced when temperatures climb above 10° C (50° F) in the spring.

Symptoms of Damage

Winter wheat rarely shows symptoms until spring. These symptoms appear on the leaves as dashes, streaks or yellow stripes parallel to the veins. Leaves become increasingly mottled until the green areas disappear and the leaves die. Infected plants are stunted; the degree of stunting depends on how early the infection took place. Wheat spot mosaic virus, which is similar to wheat streak mosaic virus, is spread by mites, has a comparable life cycle, and may sometimes be present in winter wheat.

Wheat infected at an early tillering stage stops growing and produces few to no heads. Infection at late tillering to early jointing stages results in head formation but the flowers may be sterile. With late season infection during jointing to boot stage, the flowers are fertile but kernels are reduced in size. Fall-infected winter wheat plants do not produce grain the following season. One study found that stunted and diseased plants yielded 78% less than healthy plants, and seed milling quality was reduced substantially.

Scouting Techniques

Mites in large populations on wheat will cause the leaf blades to curl upward and inward. Tips of new leaves are often caught in the curled leaf above it; this may indicate the presence of the mites and virus. A microscope or a good magnifying glass is necessary to see the mites.

Economic Thresholds

None available.

Control Tips

This disease can be controlled or reduced to a minimum by following certain cultural and agronomic practices. The key control method is to disrupt the life cycle of the wheat curl mite by preventing infection of winter wheat. Mites that survive the winter on winter wheat increase rapidly during the warm spring and summer weather and are blown to nearby hosts.

Do not sow winter wheat near immature spring wheat or other cereals. Seed winter wheat after spring crops are mature. Control all volunteer host plants at least 2 weeks before winter wheat is planted including adjacent fields. The mites cannot survive longer than 10 days in the absence of living cereal plants. Plant winter wheat as late in August or September as possible to avoid the period when mites move from late-maturing spring cereals.

Do not reseed a severely diseased winter wheat field with spring wheat. Diseased winter wheat plants are difficult to eliminate completely.

There are no pesticides available for the control of the mite or virus.

Fusarium Wilt

This fungal disease invades flax through the roots, killing seedlings and older plants.

Host Crops

Flax

Biology

This disease is caused by a seed-borne and soil-borne fungus that invades plants through the roots, and continues growth inside the water-conducting tissue. The fungus interferes with water uptake. Warm weather favours the disease. The fungus persists in the soil, while the mycelia and spores survive for many years in flax debris and other organic tissue. Spores dispersed by wind and rain spread the fungus from one field to another.

Symptoms of Damage

Seedlings may be killed shortly after emergence. Delayed infections cause yellowing and wilting of leaves, followed by browning and death of the plant. The roots of dead plants appear ash-grey. The tops of wilted plants often turn downward, forming a "shepherd's crook". Affected plants are usually scattered in patches throughout the field.

Scouting Techniques

Look for patches of wilted or prematurely dead plants exhibiting the "shepherd's crook".

Economic Thresholds

None available.

Control Tips

The most important control method is the use of available moderately-resistant varieties. Crop rotation of at least 3 years between flax crops helps to maintain low levels of inoculum in the soil.

Pasmo

Pasmo seldom causes serious damage. Occasionally, it can cause defoliation and premature ripening. Depending on the timing and severity of the infection, this disease can reduce the yield and quality of seed and fibre. Most losses are due to premature ripening and loss of seed during harvest.

Host Crops

Flax

Biology

Pasmo infections increase with prolonged wet periods in late summer and autumn. The pasmo pathogen is

seed-borne. It also overwinters in the soil on infected flax stubble. Spores, dispersed by wind and rain, cause the initial infections on leaves and stems. It attacks above-ground parts of the plant.

The disease is more common in Manitoba with its moist climate than in the drier production areas of Alberta and Saskatchewan. Although flax is most susceptible to pasmo in the ripening stage, it can occur early in the season when warm, moist conditions prevail.

Lodging favours the development of pasmo, because of increased humidity within the crop canopy. This leads to patches of dead plants completely covered with the fungus.

Symptoms of Damage

Pasmo is characterized by circular, brown lesions on the leaves and by brown to black infected bands that encircle the stem. These bands alternate with green, healthy bands, making pasmo easy to identify. Flowers and young bolls are also blighted. Older bolls are discoloured and contain shrivelled or non-viable seed.

Scouting Techniques

Look for banding of the stems and browning of the bolls.

Economic Thresholds

None available.

Control Tips

Most commercial varieties lack resistance to this fungus. Pasmo can be controlled by using a crop rotation of at least 3 years to non-host crops and using clean seed.

Early seeding, at the recommended rates, can reduce infection by avoiding high moisture conditions in the fall.

Anthracnose

This disease can cause yield losses in excess of 50%.

Host Crops

Lentils, dry beans, and field peas (affected by different species of the fungus)

Biology

Spores overwinter on seed and infected lentil stubble. The spores are released during the spring and early summer. Soil-borne spores infect and kill the lower leaves and can cause premature plant death. Upper plant parts are usually infected later in the season from spores that are spread by splashing rain. Wind plays little role in the spread of this disease other than the fact that the fungus can be spread by dust during harvest.

Spore production is favoured by soils with high pH and cool to warm wet weather during June and July. Nutritionally-stressed crops are especially susceptible.

Symptoms of Damage

Brown lens-shaped lesions appear on the leaves. Small, bristle-like, spore-bearing structures appear on affected stems and leaves. The crown and lower stem areas become bleached and then turn brown. The disease can cause plant defoliation and premature death. Small black fruiting bodies are produced on dead tissue. Crown infections reduce plant vigour and cause premature ripening.

Scouting Techniques

Typical field symptoms are lodged plants with abnormally dark-brown stems. The lesions appear on the pods, stems, leaves, and seed. They are grey to black in colour and appear sunken. A salmon-coloured ooze may appear in the centre of the lesion. Small, black pepper-like spots will eventually appear in the lesions. The lesions may start out as small black spots. In mid-season, the leaves may start to fall off rapidly. The leaf veins will appear darkened. The stem will darken in colour and appear weakened.

Economic Thresholds

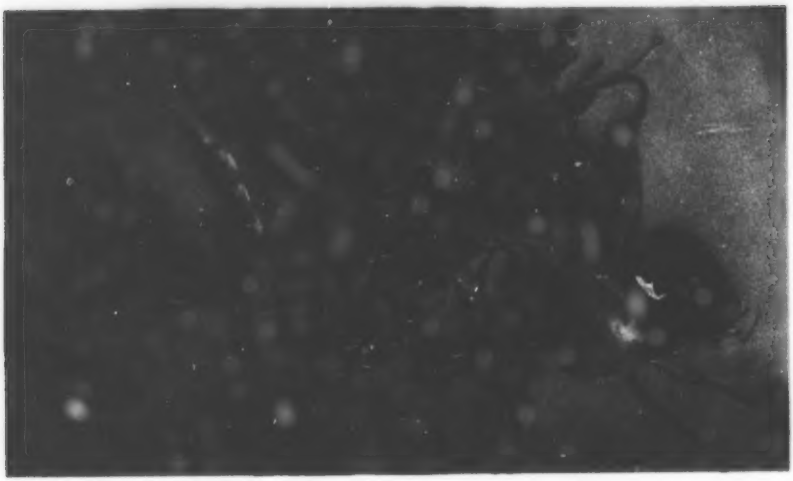
None available.

Control Tips

Follow a crop rotation of at least 3 years between lentils and field peas. Plant disease-free, treated seed.

Choose a less susceptible or resistant cultivar and use a recommended foliar fungicide if required.

Ascochyta



Ascochyta blight is a widespread disease of lentils. The lesions reduce yield by weakening the plant. If the disease hits early, the flowers will drop off before the pods can be produced, further reducing the yield. It also stains the seed, resulting in downgrading or rejection.

Host Crops

Lentils, field peas and fababeans

Biology

The spores overwinter on crop residues and do not survive in soil. The disease is carried on the seed or infected stubble. Ascochyta spores, formed in fruiting bodies on infected crop debris, can be spread by wind to neighbouring fields. Later in the summer and within fields, it is mainly spread by splashing rain. Infected plants produce infected seed and stubble. Wet weather in late summer can result in extensive pod and seed infection.

Symptoms of Damage

Light-grey to tan coloured spots and lesions appear on the leaves, pods, and stems. The leaf spots are usually white to purplish in colour. They have indefinite margins and are round to irregular shape. The lesions have a dark-brown margin. The stem lesions are long and purple. Later, tiny black pepper-like spots appear in the centre of the lesions. These are the fruiting bodies of the disease.

Scouting Techniques

In wet weather, the lesions may coalesce, resulting in premature leaf drop and defoliation. The tips of severely-diseased stems wilt, turn brown, and die. The crop looks blighted. Later in the season, lesions may form on the pods, infecting the seed.

Seed may be infected before harvest or while the crop is in the swath. Infected seed turns partly or entirely brownish-purple. Severely-infected seed may be shrivelled. Tiny black spots may appear on the surface of infected seeds. Clusters of brown spots often form on the leaves, upper stems and pods. These brown fruiting bodies distinguish Ascochyta from Anthracnose.

Economic Thresholds

None available.

Control Tips

Each host crop is affected by a specific ascochyta blight fungus. Thus, ascochyta from one pulse crop will not infect a different pulse crop in a rotation. With lentils, follow at least a 3 year rotation (i.e., a 2 year break) using a cereal, oilseed, or other pulse crop. The rotation should be longer (up to 4 years) if the pulse crop residue is resistant to breakdown (e.g., fababeans).

Chilean types of lentils are more susceptible to the disease than the Persian types.

Plant certified, disease-free, treated seed. Plant when soil temperatures are warm to reduce seed-borne infection.

Foot Rot and Mycosphaerella Blight

These diseases are closely related and can cause serious losses in peas particularly in the higher moisture regions of the Prairies.

Host Crops

Field peas

Biology

Both fungi are stubble, seed, and soil borne and can survive for several years in the soil as resting spores. Initial infection occurs as the plant shoots come in contact with resting spores or by the fungus growing from seed across the point of attachment to the seedling. Infection from the seed develops as a foot lesion. Spores are produced from reproductive bodies of the fungus and released during wet weather to initiate leaf infection. During the growing season, new reproductive bodies are produced and release spores during wet periods to establish new infections.

Symptoms of Damage

Symptoms of foot rot usually begin at the point of seed attachment and extend as a bluish-black lesion to above the soil line.

Blight symptoms occur on leaves as small, purple lesions with indefinite margins that turn brownish-black and develop a target-like appearance. Lesions coalesce and leaves may dry up but remain attached to the stem. The lesions on the stem are purple and may extend 10 mm (3/8 in.) above and below the point of leaf attachment. Infection of the flowers cause the blossoms to drop. Small, purple lesions develop on infected pods. The pods may shrink if the infection is severe. Infected seeds may show various degrees of shrinkage and discolouration or they may show no signs of infection.

Scouting Techniques

Look for bluish-black lesions on the stem. Note that stem lesions may merge and give the entire lower stem a bluish-black appearance. Infected pods are covered with small, purple lesions. The pods may appear shrunken if the infection is severe.

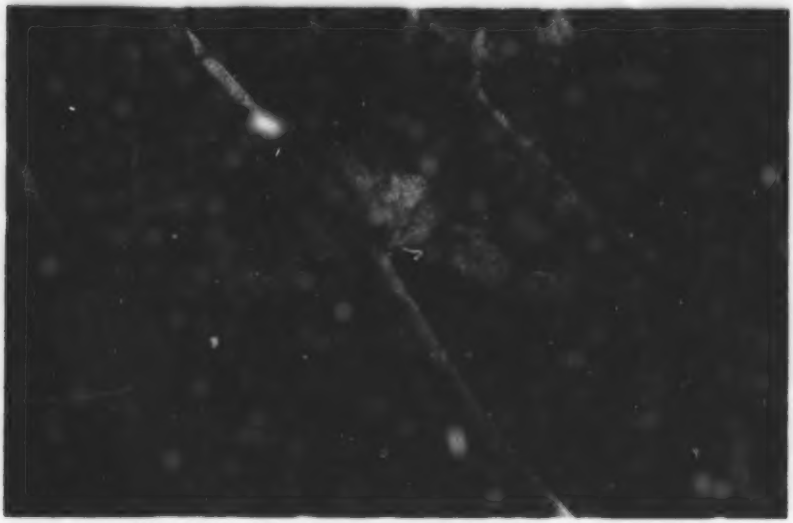
Economic Thresholds

None available.

Control Tips

Use disease-free seed and follow a 5-year crop rotation. Plant peas as far away as possible from previously infected fields. Cultivate crop residue under immediately after harvest. Treat seed with a recommended fungicide.

Powdery Mildew



Powdery mildew is a widespread disease that is often most prevalent on late-maturing field peas. In severe infestations, brown, pitted spots may occur on pods and the seed may be visibly affected. Premature ripening may result in shrunken seed.

Host Crops

Field peas

Biology

Powdery mildew overwinters on plant debris. It appears as cottony-white to tan fungal colonies and yellowed blotches on the upper and lower surfaces of the leaves. It develops more severely on the lower leaves but it can infect any of the leaves in cool, humid weather. When the disease is severe, the peas are stunted, turn yellow, and defoliate.

A lush stand of peas is an ideal environment for powdery mildew development. Dew formation and lack of rainfall also favour the development of the disease. Optimum temperatures for development are between 20–25° C (68–75° F). Rain showers are actually disruptive to the spread of powdery mildew. The inoculum is spread by wind. Once it is established, powdery mildew increases very rapidly.

Symptoms of Damage

Symptoms consist of a light, greyish, powdery growth on the leaves, pods and occasionally on the stems. This powdery growth is easily rubbed off. As the plant ages, tiny fruiting bodies of the fungus often form in the powdery growth.

Scouting Techniques

Look for powdery white growth on leaves and pods. They develop as spots that enlarge and merge to cover the entire surface of the leaves, pods and stems.

Economic Thresholds

None available.

Control Tips

Early seeding is recommended because powdery mildew infection is more damaging on late-maturing pea crops. Most varieties are susceptible to powdery mildew but resistant varieties are available. Consult the provincial seed guide for current information. Crop rotation with non-related crops will help, depending on climatic conditions. Field isolation may assist in reducing infection which occurs by wind movement.

Avoid heavy application of fertilizer.

Foliar fungicides should only be necessary when the disease appears early in the growing season or if the crop was planted late.

Root Rot (Damping Off)

(No photograph available)

Root rot occurs wherever peas are grown on the Prairies. Although both field and processing peas can suffer serious damage, field peas usually suffer less damage.

Host Crops

Field and processing peas

Biology

The fungi causing root rot are soil borne. Root rotting fungi can attack any part of the root system and even the lower portion of the stem at the soil line. When young seedlings are infected with root rot, they usually die. Infected plants may appear yellowed and stunted.

Symptoms of Damage

The lower stems and roots develop brown to black lesions. With severe disease, the below ground parts of the plant are constricted, rotted and dark-brown. Plants that are severely affected appear stunted, lose their lower leaves and die prematurely.

Scouting Techniques

Look for patchy stands because of missing plants in the rows. Affected plants may appear stunted, wilted and prematurely ripened and have root decay.

Economic Thresholds

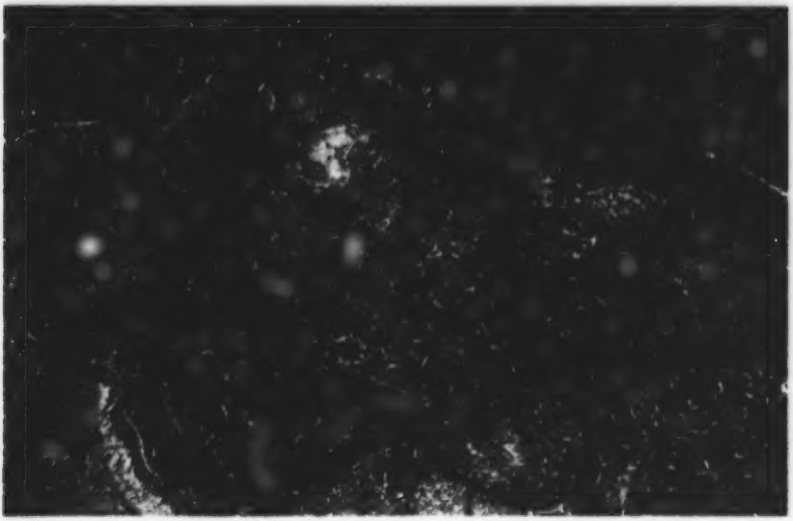
None available.

Control Tips

Seed treatment offers some protection to the developing seedlings, especially under cool, wet conditions when emergence may be delayed.

A 5-year crop rotation is also useful in preventing the build up of root rot organisms in the soil. Do not include dry beans, fababeans, or alfalfa in rotations containing peas. Avoid seeding into poorly-drained and low-lying areas.

Early Blight



Leaves are often killed, reducing yields, and tuber infections make the diseased potatoes unmarketable. It is most severe on maturing or under-fertilized potato vines. The disease often first appears in late July.

Host Crops

Potatoes

Biology

Mycelium and spores overwinter in crop residue (dead leaves and vines, infected tubers). Spores may be carried to leaf surfaces by splashing water or wind.

The spots on the lower leaves enlarge and develop a characteristic "target spot" i.e., irregular, concentric rings in the dead tissue. A narrow light green to yellow halo frequently surrounds the spot. The spots may enlarge and coalesce, causing the leaflets to die. Secondary infections occur when spores from primary lesions are spread to healthy leaves. Lesions may develop on stems, but it is rare for significant injury to occur from this infection. Tubers may become infected when they are lifted through soil infested with spores that are concentrated at ground level.

Symptoms of Damage

The first symptoms are small spots (dry and papery in texture) that become

oval to angular, dark-brown to black spots as they expand. Lesions first appear on the older, lower leaves, spreading to the younger leaves under favourable weather conditions.

Advanced lesions often have angular margins as they move up to leaf veins. They also often have a characteristic "target" appearance because of the concentric rings of raised and depressed necrotic tissue.

Although rare, tuber infection may occur resulting in irregular, brown-black, sunken spots, surrounded by a raised violet border. The underlying tissue shows a brown, corky, dry rot more than 2.5 cm (1 in.) deep.

Scouting Techniques

Inspect fields after the plants reach 30 cm (12 in.) in height to detect early infections. This disease develops best when the leaves of adjacent rows touch because this closeness provides optimum conditions of high humidity, leaf yellowing of lower leaves, and moderate canopy temperatures.

Look for small, dark-brown to black spots on older leaflets on the lower portions of plants. Note that the fungus can often be recovered from healthy-looking leaf tissue as young leaves and crops heavily fertilized with nitrogen do not generally exhibit symptoms.

Because the fungus overwinters in the field on dead leaves and vines or on infected tubers, early blight will initially be found along margins of fields that border those planted to potatoes the previous season. Early blight is often more severe when the potato crop has been under stress, ie., poor nutrition, injury, insect damage, or drought.

Economic Thresholds

None available.

Control Tips

Control with 2 year rotation, good fertility, and foliar fungicides. No truly resistant cultivars are available. Highly susceptible cultivars should be avoided where losses to early blight are expected. Early maturing cultivars are often very susceptible to early blight. The early variety can act as a source of infection for later varieties in adjacent fields.

Fungicides are important in suppressing damage caused by the early blight fungus. Consult with provincial agricultural representatives for current fungicide recommendations. Fungicide applications should begin just after bloom or at the first sign of infection, whichever is earlier.

Disease forecasting models that will lead to more effective timing of fungicide applications are available. Weather data can be used to predict the onset of early blight and the timing for the first fungicide applications.

Late Blight

Late blight has the potential to be an extremely destructive potato disease in the Prairies. It can attack both tubers and foliage at any stage of development. If no controls are implemented, entire fields can be destroyed.

Host Crops

Potatoes

Biology

When conditions are favourable, the fungus can spread rapidly through the crop, causing complete and rapid blighting of foliage. The tubers can be infected while they are in the ground, in cull piles, or in storage.

The spores are carried to nearby fields primarily by wind. They require water to germinate and penetrate the potato tissue. This can be provided by rain, dew, sprinkler irrigation and very high relative humidity.

The lesions on leaves and stems become visible as small flecks within a few days after infection, expanding to form water-soaked, grey-green areas on the leaf. These lesions may be surrounded by a circle of light green tissue. The dying tissue turns grey to tan and becomes dry within a few days. The disease may also develop on leaf petioles and stem tissue.

Under moist conditions, spore production begins. The fungus may appear as a white, mildew-like growth at the edge of the lesion, usually on the underside of the leaf. This white growth distinguishes late blight from several other foliar diseases of potatoes.

The spores are carried by wind and rain to healthy plants where the disease cycle begins again. The fungus can complete many reproductive cycles in a season. Thus, once established, the disease may spread rapidly.

Tubers are infected by spores washed from lesions to the soil. Tuber infections are characterized by patches of irregular, small to large, slightly depressed areas of brown to purplish skin. Cutting just below the skin reveals a dark, reddish-brown, dry, corky rot.

Symptoms of Damage

Field scouting should be concentrated in areas of the field most likely to have high moisture, dew, or relative humidity for the greatest length of time (e.g., low spots, areas shaded by windbreaks).

Computer-based programs are available to track weather conditions and help predict or forecast when the disease may occur. Disease forecasting programs predict when environmental conditions favour disease and recommend when fungicide applications may be needed. As the risk of disease becomes greater, crop monitoring should be intensified.

Early symptoms are small, light to dark green, circular to irregular-shaped, water-soaked spots. These lesions usually appear first on the lower leaves. Lesions often begin to develop near the leaf tips or edges, where dew is retained the longest.

During cool, moist weather, these lesions expand rapidly into large, dark brown or black lesions, often appearing greasy. The lesions are not limited by leaf veins, and as new infections occur and existing infections coalesce, entire leaves can become blighted and die within a few days. The lesions may expand down petioles and stems of the plant.

(continued next page)

(Late Blight continued)

Scouting Techniques

Late blight, requires a cool, moist environment. If infected leaves are examined in the early morning or during other cool damp weather, a white mildew growth may be seen on the underside of those leaves. A pale green to yellow border is often present around the lesions.

Plants severely affected by late blight have a distinctive odour resulting from the rapid breakdown of potato leaf tissue. A similar odour may occasionally be detected after chemical vine-kill or a severe frost.

Late blight infection of tubers is characterized by brown to purplish irregularly shaped, slightly depressed areas of variable size on the skin. These symptoms may be less obvious on russet and red-skinned cultivars. A tan to reddish-brown, dry, granular rot is found under the skin in the discoloured areas, extending into the tuber, usually less than 12 mm (1/2 in.). The extent of rot in a tuber depends on the susceptibility of the cultivar, temperature, and the

length of time after the initial infection. The margin of the diseased tissue is not distinct. The margin is marked by brown finger-like extensions into the healthy flesh of the tuber. Severely infected tubers may display extensive rot, often accompanied by soft rot.

The mildew-like growth of the causal fungus may appear on the surface of tubers.

Economic Thresholds

None available.

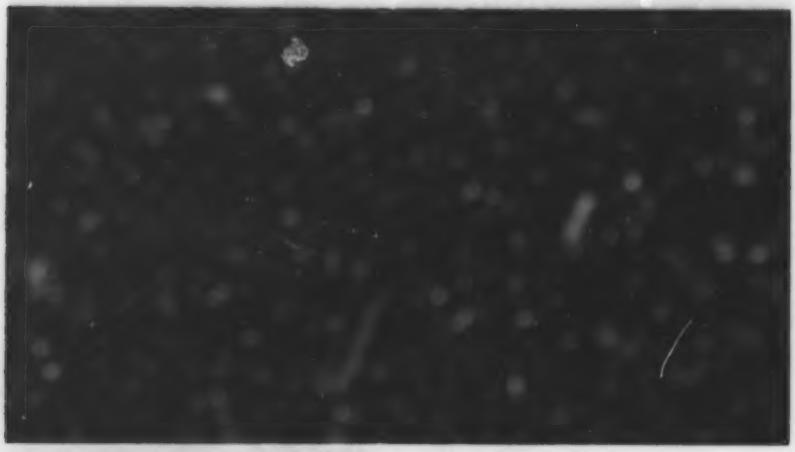
Control Tips

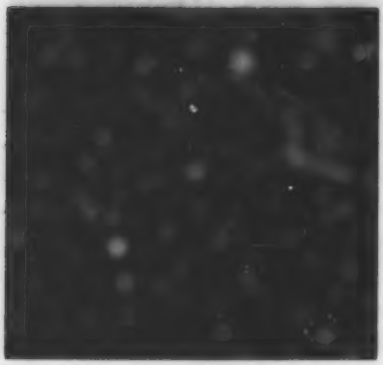
Effective control of this disease requires implementing an integrated disease management approach. The most important measures are cultural practices like planting only healthy, disease-free seed tubers, keeping a clean operation (destroy all cull and volunteer potatoes), avoiding frequent or night-time irrigation of potatoes, hilling to reduce the incidence of tuber infection, starting to harvest after the vines are completely dead (2 weeks after vine killing), managing cull piles, rotating crops, and ensuring that tubers are dry when placed in storage.

Resistant cultivars and fungicides can also be utilized. Select varieties with resistance to late blight wherever practical. Various publications available through agricultural representatives provide information on resistant varieties.

Fungicides are usually applied when potato plants are 15–30 cm (6–12 in.) high or when conditions have been determined to be favourable for infection. Fungicides are most effective if applied when the canopy begins to close within the row. Applications should continue, as needed, throughout the growing season. Complete coverage is essential when using protectant fungicides. If late blight is present in a field, a combination of protectant and systemic fungicides should be used. Consult the provincial Guide To Crop Protection for information on currently approved fungicides.

Downy Mildew





Downy mildew can cause severe yield losses during wet years, especially in poorly-drained fields.

Host Crops

Sunflowers

Biology

The fungus is soil borne, wind borne and seed borne. The fungus may persist in the soil for 5–10 years. Under cool, water-saturated soil conditions, the spores germinate into mycelia that enter the seedling's roots and spread throughout the entire plant. When infected plants rot and are tilled into the soil, the fungus forms the resting stage. It will germinate again when conditions are favourable.

If seedlings are infected several weeks after emergence, they exhibit the typical leaf symptoms of downy mildew but do not exhibit the stunting that is usually associated with the disease. Plants infected after the 4-leaf stage may develop a thickened, club-like root , become stunted, and not show any

foliar symptoms. These plants are prone to drought stress and lodging. Mature plants are often stunted, producing normal sized heads with few if any seeds.

Secondary spread of spores (ie., by wind) may result in the development of small, localized, angular chlorotic spots on the leaves. These spots may coalesce and resemble a systemic infection. However, the foliar lesions rarely produce a true systemic infection.

Symptoms of Damage

Symptoms can be seen at all growth stages. Seedlings appear dwarfed and chlorotic (yellowed) and may have thickened, leathery leaves. In high humidity, the undersides of leaves may be covered with white, cottony growth.

Yield losses from downy mildew can be substantial depending on the percentage of infected plants and their distribution within the field. If infected plants are scattered randomly throughout a field, yield losses probably will not be observed until infection exceeds 15% due to the compensating ability of healthy plants adjacent to infected plants. When the disease is in a localized area, such as a low spot in a field and all plants are infected, the yield loss will be much greater.

Scouting Techniques

Diseased plants are most often noticed alone or in standing water. Severely-infected plants may die before or shortly after emergence or in the seedling stage. The few plants reaching maturity seldom produce viable seed. The heads on these plants usually face straight up, making them more vulnerable to bird feeding.

Note that dwarfing and distortion of leaves also are symptoms typical of herbicide drift damage, especially 2,4-D and related phenoxy compounds. However, herbicide damage never exhibits the white appearance (fungal growth) on the underside of the leaves nor the chlorosis typical of downy mildew.

Economic Thresholds

None available.

Control Tips

Use resistant varieties. Many commercial hybrids are resistant to several but not all races of downy mildew.

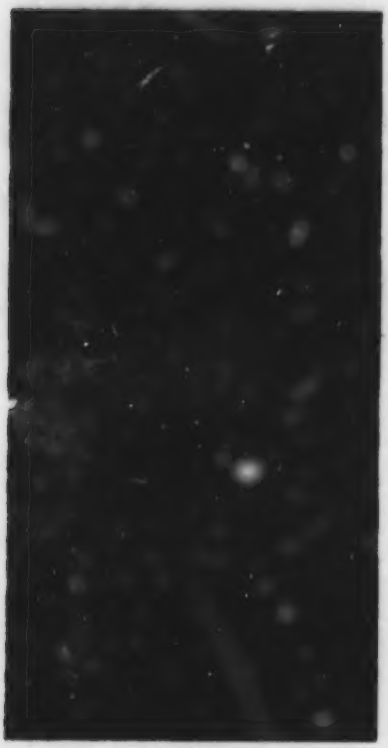
Use an extended crop rotation of 4 years between sunflower crops.

Do not seed sunflowers in lowlands that flood frequently and maintain high inoculum levels from alternate hosts.

Control volunteer sunflower. Delay planting until soil temperatures favour rapid seedling growth.

Use a fungicide seed treatment to protect against root infection. The seed treatment does not protect against foliar infection.

Phoma



Infected sunflowers are weakened, produce smaller heads, and are susceptible to lodging.

Host Crops

Sunflowers

Biology

This soil-borne fungus overwinters in infected debris and is spread by splashing rain and by insects. Adult stem weevils feeding on the leaves cause leaf lesions whereas weevil larvae spread the fungus as they tunnel through the stem. Disease transmission through contaminated seed is minor.

Yield losses are variable, but in conjunction with stem weevil infestation, can become quite significant.

Symptoms of Damage

Phoma black stem is characterized by large, jet-black lesions on the stem, up to 5 cm (2 in.) in length. The fungus also produces lesions on the leaves, on the back of the head, at the crown or base of the stalk, and occasionally, on the leaf petioles.

Lesions usually originate at the base of the leaf petiole and spread to form spots with more or less definite margins. Under favourable conditions, the leaves wilt, petioles turn black, and the stem lesions expand to form a large, shiny, black patch. Small circular fruiting bodies of the fungus, produced on the surface of the stem, are visible with a hand lens.

Scouting Techniques

Phoma infections occur throughout the growing season but they are usually more pronounced after flowering and noticed when the stem lesions become obvious later in the summer.

Economic Thresholds

None available.

Control Tips

Failure to rotate fields amplifies problems with phoma (and other diseases). A 4-year rotation to other crops will minimize the concentration of phoma within the soil.

Although some hybrids may be more tolerant than others, none are resistant.

Controlling high populations of stem weevils may help to reduce disease transmission.

Rusts

Early infection of susceptible varieties can cause serious reduction in seed yield and oil content. Later infections cause less damage. Late planted fields of susceptible hybrids are generally more severely damaged by rust than earlier planted fields.

Host Crops

Sunflower, wild sunflower

Biology

Sunflower rust spores overwinter on the debris from infected sunflower leaves and stems. In the spring, the spores ger-

minate to infect volunteer seedlings, wild sunflowers or new young plants in nearby fields. Spore production and infection continue to occur. This "repeating stage" is the most damaging with spores being spread by wind to other fields. As the crop ripens, the spores form the overwintering stage which can re-infect next year's crop.

Rust multiplies rapidly during warm, moist weather. High nitrogen levels and abnormally high seeding rates promote excessive foliage. This, in turn, increases the humidity within the canopy and favours rust development.

Symptoms of Damage

Symptoms appear as small, pale yellow or orange spots on the upper surfaces of leaves, followed by spots appearing on the lower surfaces of leaves. A heavy infection can cause the entire leaf to die. Rust spots may also be found on the stems, petioles, bracts and back of the head. In late July or early August, the orange spots are replaced by small, dark-brown, dusty spots on both surfaces of the leaves. Black pustules of spores will be found on the stems.

Scouting Techniques

Look for dense masses of brown, powdery pustules that are scattered on all of the green parts of the plant, especially the leaves. Heavily-rusted leaves appear withered.

Economic Thresholds

None available.

Control Tips

Grow rust resistant varieties. Most oilseed and confectionary hybrids have good to excellent resistance to most races of rust.

Rotate to other crops. Destroy wild sunflowers or volunteer sunflowers. Early seeding may minimize the disease.

Sclerotinia

Sclerotinia wilt and head rot are the most important diseases affecting sunflowers.

Host Crops

Sunflowers, canola, mustard, dry beans, field peas, lentils, potatoes

Biology

Sclerotinia survives in the soil for up to 4 years as irregularly-shaped fungal bodies called sclerotia. The sclerotia germinate in the summer, producing mushroom-like structures that release wind-borne spores. The disease is favoured by extended periods of rain, several weeks prior to and during flowering.

The symptoms of sclerotinia wilt usually appear during flowering. The diseased plants may occur singly or in patches. The upper leaves droop, dry out and die. The entire plant dies quickly. Young wilted plants often turn black whereas mature plants usually remain light brown. Small irregularly-shaped bodies can be found inside the stem near the soil line. Surviving plants may or may not produce seed, depending on when the infection occurs. The heads on wilted plants generally are smaller than those on healthy plants and seed weights are lower.

Head rot is caused by wind-borne spores of the same fungus. It usually occurs late in the season, after initial flowering and extended periods of wet weather. Dead petals, on the backs of the heads, provide a place for the spores to germinate. The affected heads decay, become soft, and black sclerotia form within the heads.

Head rot also causes a decrease in oil content and an increase in free fatty acid content. The sclerotia that form in diseased stalks and heads are returned to the soil at harvest and can cause sclerotinia diseases in sunflower or other susceptible crops in following years.

Symptoms of Damage

In general, the symptoms of damage include drooping, brown or dead upper leaves; plants that turn brown or black and die prematurely; fungal bodies (sclerotia) in the stem at the soil line; soft, rotting heads with only fibrous tissue remaining; and black sclerotia in the heads.

The characteristic symptoms of sclerotinia wilt include sudden wilting of leaves, root rot, and a basal stem canker. The first wilted plants are usually seen just before flowering but most appear in patches during and after flowering. The time required from incipient wilt to complete wilting may be 4–7 days.

The first symptoms of head rot usually are the appearance of water-soaked spots or bleached areas on receptacles (the fleshy back of the head). The fungus can decay the entire receptacle and the seed layer falls away leaving only a bleached, shredded skeleton interspersed with large sclerotia.

Scouting Techniques

With sclerotinia wilt, young wilted plants often turn black. Mature plants usually remain light brown. Small, irregularly-shaped, sclerotia can be found inside the stem, near the soil line.

The bleached, skeletonized heads associated with head rot are very obvious in the field, even from a distance. Infected heads usually shatter during combining and any remaining seeds are lost. Usually, the seeds are not decayed but many are empty. The large sclerotia in the heads may be 12 mm (1/2 in.) or greater in diameter and many are harvested along with the seed. Large sclerotia mixed in with seed confirms that a field contained head rot.

Economic Thresholds

Wilt occurs whenever sunflower is planted on sclerotinia-infested soil and can cause severe yield loss. On the average, infected plants yield less than 50% of healthy plants. Sclerotinia wilt also leads to increased levels of sclerotia in the soil which, in turn, can result in the removal of fields from sunflower production for many years.

Control Tips

The key to managing these diseases is to plant in non-infested soil and prevent the buildup of sclerotia in soil.

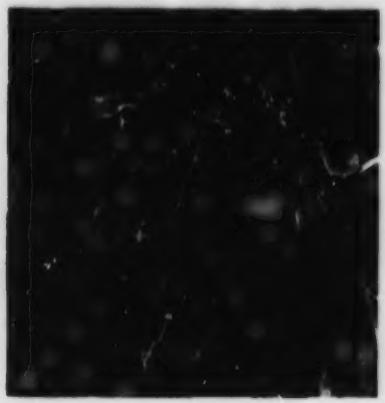
Monitor fields for sclerotinia diseases and rotate crops. Follow a crop rotation of 5 years between susceptible crops.

To minimize head rot, plant to maximize air circulation. Locate new plantings as far away as possible from fields where sclerotinia was know to be a problem in the previous 4 years.

Although no resistant hybrids are available, progress is being made in reducing the susceptibility of sunflowers to sclerotinia.

Verticillium Wilt

Verticillium wilt can reduce sunflower yields on lighter soils by up to 50%.



Host Crops

Sunflowers, potatoes, alfalfa, sweet clover

Biology

The fungus is seed and soil borne. It survives as small, black, resting bodies in diseased sunflower debris and broadleaved weeds. The root tips of sunflower plants are invaded and, eventually, all parts of the plant

become affected. When the plant dies, the fungus produces the black fungal bodies that return to the soil with the plant debris. The fungus is able to survive in the soil for several years.

Symptoms of Damage

The symptoms may appear early in the season but are most common near the time of flowering. Diseased plants usually occur in groups of a few to many plants. Symptoms develop first on the lower leaves and gradually appear on leaves farther up the stem. The leaf tissue between the veins yellows and becomes necrotic, while the areas near the veins remain green. This produces a mottling effect.

Cross-sections of the stem reveal a brown discolouration of the vascular tissue (visible as a brown ring).

Severely-diseased plants die early, before seed development. They exhibit brown, withered leaves and black streaks at the base of the stem. Masses of tiny, black, fruiting bodies are produced inside the stalk. With light infestations, the diseased plants also die prematurely but the leaves may only be yellow and not exhibit the typical mottling.

Scouting Techniques

At or near flowering stage in single or groups of plants, look for yellowing between leaf veins. These areas turn brown and die. Severely-infected plants will turn brown, starting at the bottom leaves, and die prematurely.

Economic Thresholds

None available.

Control Tips

Plant only resistant varieties. Many oilseed and some confectionary hybrids show resistance to verticillium wilt.

Rotations of at least 4-year spacings between sunflower crops, 2 of which must be cereals, are recommended to help prevent this disease.

Scouting for Weeds

Field scouting is the most important part of an integrated weed management program. Only through routine monitoring will you be aware of developing weed problems. The key to a good weed management program on any field is the correct identification of the weed species present. This can only be accomplished with a good field scouting program. It's impossible to know which weed control strategies to try until you know which weeds you are dealing with.

Useful Tools for Weed Scouting

Scouting is easiest when you carry some basic tools and equipment into the field with you. These include a clipboard with scouting forms, field maps, a hand trowel, a sharp knife, a hand lens, plastic and paper bags for collecting samples of unknown weeds, labels for bags, a 0.25 square metre sampler, and pencils and markers. Optional extras that can make the work more efficient include a pocket calculator for calculating weed densities and a GPS unit. GPS units are useful for marking the location of weed patches, which will make it easier to find those patches and monitor the effectiveness of your weed control program as time goes on. It is also a good idea to have some basic weed reference guides (including this publication) and your provincial *Guide to Crop Protection* with you or in your vehicle.

For weeds in field crops, follow these steps:

1 Walk a zig-zag pattern through the field, stopping at least 5 times at widely-separated points along the way. Your pattern should take you across the entire field, and allow you to finish where you started (e.g., the approach where you left your truck). Note that some weeds may be concentrated in low, wet, or saline spots in the field or along field margins. If such weeds are a problem, adjust your sampling accordingly.

2 While walking through the field, identify all weed species present and record the growth stage of each

weed, especially if herbicide controls are being considered. Note the condition of the crop (if it is a good stand or not) and record the growth stage of the crop. A good crop stand that is more advanced than the weeds is more competitive and suffers less yield loss.

3 If the weeds appear to be concentrated in specific areas of the field, draw a map of the field and mark their locations. Making a field map of these weed patches will make future weed control planning easier. Hand held GPS units are useful for weed mapping. Mapping will also aid in determining the extent of the weed problem over the whole farm and calculating control costs and potential rotational crops.

4 At each field stop, determine the number of weeds present. For best results, take 4 or 5 samples at each of your 5 major field stops. Randomly take your samples by tossing a 0.25 square metre count hoop or a brightly coloured ball into the field. Tie some bright ribbon to your count hoop or paint it a bright colour to make sure you don't lose it in the field. This will give you a total of 20 to 25 counts per field. Consider taking more samples if the field is large (greater than 100 acres) or non-uniform (with many low spots and hills). With this data, you will have an excellent picture of all the weed problems in a field.

5 After all counts have been taken, total the count for each weed and divide by the total number of counts. This will give the average number of weeds per 0.25 square metres. Multiply this number by 4 to get an average number per square metre. Most threshold information for weeds is based on a weed density per square metre.

Weed Descriptions

The following weed descriptions provide information on the identification, biology, and the effects on crop quality and yield for the most common and troublesome weeds. Control tips are also offered that will help with the management of each weed.

A truly integrated weed management program combines different agronomic practices to manage weeds so that the reliance on any one weed control technique is reduced, and the effectiveness of these practices is maintained for future use. The control tips offered for each weed represent one or two tools that should be used in combination with a variety of other techniques to develop a truly integrated weed management strategy for your farm. For further information on integrated weed management contact your agricultural representative. The current *Guide to Crop Protection*, contains the most up to date information on weed control with herbicides.

Barnyard Grass

A common weed that can reduce yield and make harvesting difficult, especially in dry beans and potatoes.

Biology

This weed is a robust, tufted, annual grass. The stems usually branch from the base, are flattened, and spread over the ground. The green leaves are 6–15 mm (1/4–1/2 in.) wide, 5–50 cm (2–20 in.) long, flat or V-shaped, keeled below, and somewhat rough or smooth above. The spikelets are green to purple, numerous, and located on branches of the flowering stem. Each spikelet has 1 floret and 2 empty glumes. The empty glume is often long-awned. Barnyard grass produces about 7,200 seeds per plant.

Barnyard grass prefers warm, moist, soil conditions. It may become a problem in irrigated row crops (e.g., sugar beets and potatoes) because, the seeds float and are easily spread by flooding or heavy irrigation.

Scouting Techniques

Take a minimum of 20 weed counts across the field. Ensure that you check

any low spots for patches because seeds may have collected in such spots when water drained into them. Also, check the field edges because this weed often moves in from field borders.

Effects on Crop Quality

This tough, fibrous weed can cause problems in harvesting equipment, especially when harvesting dry beans and potatoes.

Threshold/Yield Loss

Barnyard grass can reduce yields in most crops. This weed is less competitive than wild oats but more competitive than green foxtail in cereals. Because it is susceptible to shading, it is usually not a serious problem if it emerges after the establishment of a tall, vigorous crop.

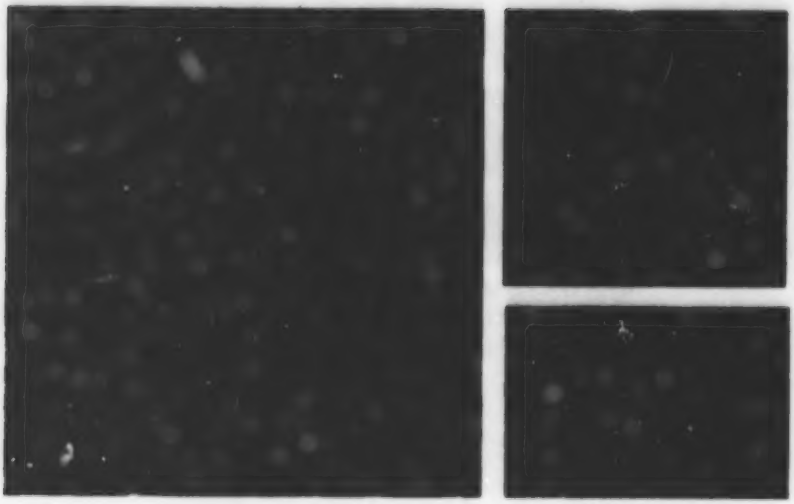
Control Tips

Positively identify this weed. Barnyard grass resembles green foxtail at early stages and is often mistaken for it. Some herbicides that control green foxtail don't control barnyard grass.

This weed has the ability to root at the nodes and can re-establish itself after a light cultivation. Barnyard grass may not be controlled by tillage in minimum tillage programs or when direct seeding with sweeps and you will have to adjust your weed control strategy accordingly.

Herbicides registered for control of barnyard grass are available in cereal, oilseed and pulse crops.

Green Foxtail



This weed can cause yield reductions of about 25% in wheat when foxtail populations reach 400–500 plants per square metre (sq. yd.).

Biology

An annual, reproducing by seed, the stem is erect, branching at the base, and 20–60 cm (8–24 in.) tall. The leaves are flat, without hairs, rough, and have a pointed blade, 5–25 cm (2–10 in.) long. The green heads are cylindrical, tapering toward the summit, 2.5–10 cm (1–4 in.) long, soft, and bristly.

Green foxtail is a heavy seed producer. It produces about 34,000 seeds per plant. However, it is a poor competitor, unless it grows in dense stands. Seeds remain viable in soil for about 3 years. Seeds buried deeper than about 7.5 cm (3 in.) do not germinate.

Foxtail is shallow-rooted and does not grow well in cool, dry conditions. It is slow germinating but grows rapidly. It thrives under conditions of relatively high temperatures and light. Under low light intensity, green foxtail grows very poorly and remains small. Temperature, depth of seed burial, and dormancy each play an important role in the control of germination and the emergence of green foxtail.

Germination occurs readily at temperatures from 20–25° C (68–77° F). These temperatures are common during late May and early June. However, germination may continue up to September. The main flush of growth occurs in June. Subsequent germination usually coincides with rainfalls and moist to wet soils.

Scouting Techniques

Take a minimum of 20 weed counts across the field. Scout frequently because under hot conditions, green foxtail can advance through it's growth stages quickly, potentially escaping the window for herbicide application.

Effects on Crop Quality

Reductions in grain quality can occur. In addition, dockage contributes to cost of grain storage, transportation and seed cleaning.

Threshold/Yield Loss

Yield losses can be especially severe during seasons that start with hot spring temperatures. Green foxtail can cause economic loss when it germinates and emerges at the same time as small grain. Yield loss depends on the number of green foxtail per square metre (sq. yd.), the stage of the weeds and the crop, and weather conditions. If the weed emerges before or at the same time as the crop, green foxtail may be competitive enough to cause yield losses. Green foxtail can reduce yields by 10–15% when wheat is planted late.

Green foxtail is rarely a problem in a competitive stand of barley. As a conservative rule, foxtail control should be considered when 100–150 foxtail per square metre (sq. yd.) are evident before the 2 leaf stage of tall varieties of spring wheat, the 3 leaf stage of semi-dwarf spring wheat, the 3 leaf stage of tall durum, and the 4 leaf stage of semi-dwarf durum.

Green foxtail has little effect on canola yields. Densities as high as 100 plants per square metre (sq. yd.) reduce canola yields by less than 5%.

Additional yield loss information for green foxtail is available in the current *Guide to Crop Protection.*

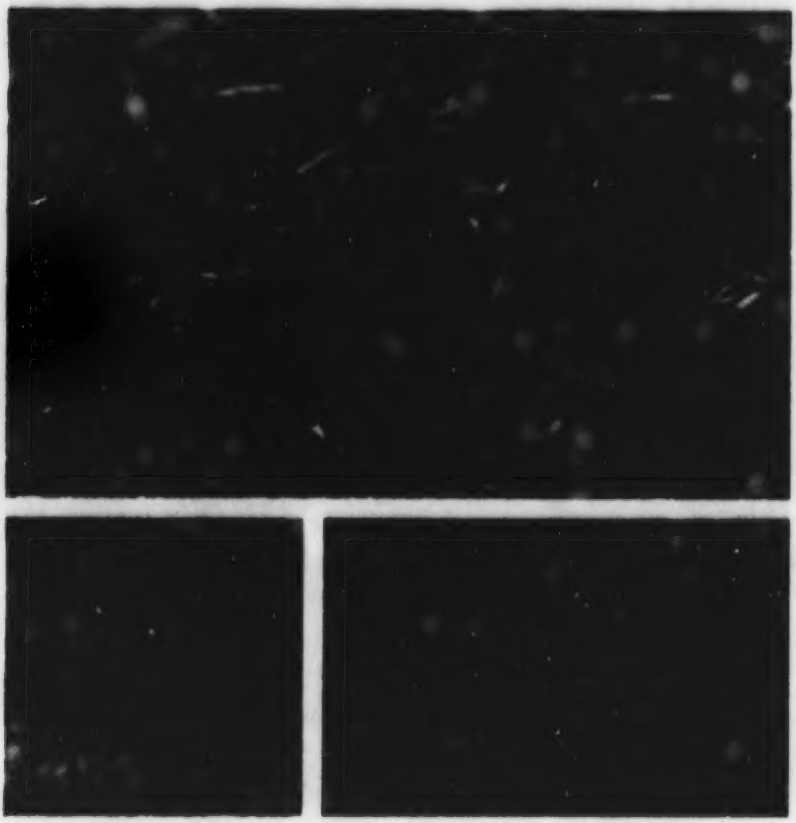
Control Tips

Because this weed is a poor competitor, it can be controlled by strong crop stands produced by early seeding and good fertilization. Barley and canola both compete well with this weed. Semi-dwarf wheat is more susceptible to foxtail competition than normal height varieties. Early maturing varieties compete by shading out the foxtail or by completing their early growth before competition starts. Early seeding and the use of slightly higher seeding rates reduce competition from green foxtail. The suppressed plants may still produce enough seed to infest the field in subsequent years.

Green foxtail does not thrive in the cool, loose soil that is often found between the crop rows of reduced tillage or zero tillage fields. Green foxtail populations generally decline under reduced or zero till crop production.

Green foxtail does well when fertilizer is broadcast across the soil surface. Banding nitrogen places the fertilizer in the soil where it is unavailable to the shallow root system of this weed.

Quackgrass



Quackgrass is difficult to control. The long running rhizomes can weigh up to 6.7–9 tonnes per hectare (3–4 tons per acre). The seeds are a serious contaminant in cultivated forage seed.

Biology

This perennial grass spreads by seed and underground rhizomes. The stems are smooth and 35–140 cm (1–4.5 ft.) high. The leaves are flat and slightly hairy on the upper surface. There are clasping auricles at the base of the leaf blade. The spikelets have 3–7 florets, attached broadside to the flowering stem. There are 2 horizontal rows on each spike. The seeds are yellow or white and can remain in the soil for more than one year before germinating. However, quackgrass propagates and spreads mainly by rhizome formation. These rhizomes also secrete a toxic substance that suppresses the growth of sur-

rounding plants and enhances the competitiveness of quackgrass (known as an allelopathic effect). Quackgrass thrives under cool, moist conditions.

Scouting Techniques

Inspect fields frequently to locate infestations early. Take a minimum of 20 weed counts across the field. Quackgrass usually occurs at high densities in localized patches within a field but can spread rapidly by its underground rhizomes. Look carefully for patches that are beginning to encroach into the field from field borders or headlands.

Effects on Crop Quality

Quackgrass can cause reductions in seed filling and the weed seeds can be a contaminant in forage seed. The rhizomes often get tangled in harvesting equipment (e.g., in potatoes).

Threshold/Yield Loss

When present in dense patches (more than 900 shoots per square metre or sq. yd.), quackgrass can reduce wheat yields by up to 100%. For example, 500 shoots per square metre (sq. yd.) cause about a 50% loss in yield. As a rule of thumb, for every 100 shoots per square metre (sq. yd.), the wheat yield will drop by about 10%. The economic threshold in canola is about 20–25 shoots per square metre (sq. yd.).

Control Tips

A multi-year integrated control plan must be used for control of quackgrass. This could include tillage, patch mowing, in-crop herbicides, and pre-harvest and post-harvest herbicides. Proper crop rotation is essential. As with some of the other weeds, the keys to control are recognizing the problem and being persistent.

Tillage may decrease quackgrass density or may spread the rhizomes increasing spread of the weed. Quackgrass patches should be tilled into the center of the patch to limit the spread of the rhizomes. In the spring, repeat tillage whenever the top-growth approaches 5 cm (2 in.). Remove rhizomes from tillage and seeding equipment before leaving quackgrass infested fields.

Herbicides are available in broadleaf crops for suppressing quackgrass. Glyphosate applied pre-seeding or post-harvest will control quackgrass, but pre-harvest applications are the most effective.

Wild Oats

Wild oats is the most serious grassy weed in the Prairies. Losses can be as high as $500 million annually across the Prairie provinces. It causes yield losses, dockage losses, cleaning costs, and lowers grade and quality.

Biology

Wild oats is an annual weed, reproducing by seed. The seedling has a counter-clockwise leaf twist and no auricles. It has hairs on the leaf margins and a membranous ligule. In the mature plant, the stems are smooth, erect, and grow up to 150 cm (4 ft.) tall. The leaves are similar to tame oats. The head is an open panicle and the spikelets usually contain 2–3 florets (up to 7). The panicle may contain up to 250 seeds, ranging from black, brown, grey, yellow, to white.

The seeds are hairy at the base and awned with a circular scar at the point of seed attachment. They can remain dormant in the soil for 7 to 8 years but most seeds germinate within 2 years. Warm, dry, fall conditions promote the loss of seed dormancy but

dormancy can be induced again the following spring under wet soil conditions and low temperatures. Wild oats prefer cool weather and moist soil.

Scouting Techniques

Take a minimum of 20 weed counts across the field. The key to identifying wild oats from wheat and barley is to look for the presence or absence of auricles (ear-like appendages wrapping around the stem where the leaf joins the stem). Wheat and barley possess auricles, while wild oats do not. Although this weed is usually randomly spread across a field, carefully check any low spots in the field for patches of wild oats, as wild oat prefers moist soils.

Be aware that herbicide resistance is a serious problem with wild oats, and make note of suspicious looking weed patches that may be resistant. The best time to scout for patches is after the wild oats have headed out and are visible above the crop.

Effects on Crop Quality

Wild oats in grain cause increased dockage.

Threshold/Yield Loss

Wild oats compete for light, moisture and nutrients, resulting in crop yield losses. Barley and canola (if stand is strong) are strong competitors, wheat is intermediate, and oats and flax are weak competitors.

Yield loss will depend on the number of wild oats per square metre and the stage of the wild oats and the crop. Wild oats is very competitive with wheat. Left unchecked, 10 wild oat plants per square metre (sq. yd.) can reduce wheat, barley and canola yields by 10% and flax yields by 20%. Additional yield loss and economic threshold information is available in the current *Guide to Crop Protection*.

Control Tips

Time of emergence of the crop relative to wild oats is critical in limiting the amount of yield loss wild oats will cause. The use of competitive crops (barley, canola, or wheat) in combination with practices that give the crop a jump on the weeds (shallow seeding, good seedbed preparation, proper fertility, herbicide burnoff or tillage timed close to crop emergence or seeding) will provide strong competition and limit the yield loss caused by wild oats.

Many herbicides are available for the control of wild oats, however, relatively few are non-Group 1 herbicides, and Group 1 wild oat resistance is a serious problem. Flax and pulse crops in particular have very few non-Group 1 herbicide options. Take the time to plan a herbicide rotation and ensure that you preserve your Group 1 herbicides for the crops that need them the most.

Canada Thistle

A strong competitor for light, moisture and nutrients, Canada thistle can cause greater crop losses than any other broadleaf weed in Western Canada.

Biology

A perennial, it reproduces with seed and freely sprouting, horizontal root stalks. The stalks run 15–30 cm (6–12 in.) below the surface. Established plants spread laterally by producing creeping horizontal roots. These roots can send up new shoots at intervals of 5–15 cm (2 to 6 in.) and spread more than 6 m (20 ft.) in one year, producing a network of root growth measuring 485 m (1600 ft.) in total length.

Canada thistle also spreads by seed with the help of "pappi" attached to the seed. This parachute-like attachment allows the seed to be borne by wind, carrying it as far as 60 metre (200 ft.) from the mother plant.

Branching horizontal and vertical roots contain an abundant food reserve. Carbohydrates stored in the roots fuel the growth of new shoots each season. A typical infestation produces 13–18 shoots per square metre (sq yd.). It grows in cultivated fields, pastures, roadsides, rights-of-way and undeveloped areas.

The seedling has oblong cotyledons. The leaves are oval to spear-shaped. The margins have numerous triangular indentations and sharp spines. The seedlings are weak competitors if they are shaded by the crop.

In the mature plant, the stems are erect, hollow, 30–120 cm (1–4 ft.) high, branching only at the top. The leaves are alternate, oblong, or lance shaped. They are slightly clasping and deeply and irregularly cut into segments with sharp spines. The purple, pink or white flowers are present in groups at the ends of branches. Canada thistle produces about 700 seeds per plant. The seeds are brown with lightly-attached white hairs.

Scouting Techniques

Take a minimum of 20 weed counts across the field. Canada thistle often occurs in large patches near field edges, shelterbelts, sloughs or potholes, and dug-outs. Sometimes you may see

caterpillars of the painted lady butterfly *(see page 28)* feeding on Canada thistle.

Effects on Crop Quality

Canada thistle can slow harvesting. Green matter in harvested grain can increase drying costs and dockage.

Threshold/Yield Loss

The weed competes for light, moisture and nutrients. Even light infestations will cause yield losses in field crops, horticultural crops and forages.

Studies show that 20 Canada thistle shoots per square metre (sq. yd.) can reduce canola yield by 24%. In wheat, 14 shoots per square metre (sq. yd.) can reduce yields by 38%.

Yield losses as high as 60% in cereals have occurred. One study indicated that 10 thistle shoots per square metre (sq. yd.) reduced barley yields by roughly 20%. Another showed that 2 thistle shoots per square metre (sq. yd.) reduced wheat yields by about 15%. Ten shoots per square metre (sq. yd.) can reduce winter wheat yields by about 20%.

Control Tips

Canada thistle requires a multi-year, integrated control strategy. This could include tillage, patch mowing, in-crop herbicides, and pre-harvest and post-harvest herbicides. The plan must include proper crop rotation. Avoid crops with poor competitive ability and no in-crop herbicide options (e.g., lentils, field peas). The key to control is recognizing the problem and being persistent with control measures.

A typical seedling in the 2-leaf stage, 14 days after emergence, will have a root that is 15 cm (6 in.) long, with as many as 18 lateral roots. At this early stage, it does not have a perennial root, so it can be killed by cultivation. However, a 3-week-old seedling can regenerate after the top-growth is clipped. Seedlings are also controlled easily with herbicides.

Tillage in late fall gives poor to excellent control. Late fall tillage, on average, reduces the number of shoots by 20%. The following season most shoots on fall tilled fields emerge 1 month later than do shoots on un-tilled fields. This delay in emergence can give the crop a strong competitive advantage. However, tillage can also aggravate a thistle problem. Small fragments often survive adverse conditions. Under favourable conditions, even a 1.25 cm (1/2 in.) length of root can generate new growth.

The top growth can be controlled in a number of crops by spraying broadleaf herbicides that suppress growth. Once absorbed, they move through the plant to the growing points in the shoots and roots. Because Canada thistle has a massive capacity to produce roots and shoots eventually growing up as new plants, killing the top-growth is like giving thistle a haircut. The only way to control the entire root system is to use a herbicide that translocates deeply into the roots. Pre-harvest glyphosate and herbicides containing clopyralid are effective at controlling Canada thistle.

Cleavers

Cleavers can be very competitive, causing significant yield losses. The trailing plants also interfere with harvesting equipment. It is a serious contaminant of canola seed, lowering seed quality.

Biology

An annual or winter annual, reproducing by seed, it prefers damp, moist soil. The seedling has oblong cotyledons, a square stem with downward pointing hairs, and true leaves in whorls.

When mature, the stems are square, with short, bristly downward pointing hooks growing on corners, generally 60–120 cm (2– 4 ft.) long and trailing. The leaves are in whorls, in groups of 6–8. They are pointed at the tip, roughened, and 2.5–7.5 cm (1–3 in.) long. The flowers are white, small, and produced in the axils of upper leaves.

The seeds are grey-brown, rough, and bristly. A single cleavers plant can produce 3,500 seeds. Because of their similar size and shape, they cannot be separated from canola seed. Cleavers seed

becomes dormant in dry soil. The seed can remain viable for 1–3 years. Seeds remain viable when eaten by animals. It is easily spread by harvesting equipment and in contaminated manure. The bristly seeds cling to the hair and wool of animals and to clothing.

Scouting Techniques

Take a minimum of 20 weed counts across the field. Check low spots for patches. Scout fields early because the weed is most sensitive to herbicides in its early growth stages.

Effects on Crop Quality

The trailing nature of the plant prevents proper crop development. The clinging bristles make crop handling and harvesting difficult. Because there is so much green material at harvest, straight combining becomes difficult, if not impossible. The seeds are similar in size and shape to canola, making them a serious contaminant of canola and rapeseed, resulting in the downgrading of these crops.

Threshold/Yield Loss

The weed competes for light and nutrients. Heavy infestations can cause yield losses. Cleavers at densities of 100 plants per square metre (sq. yd.) can cause a 20% yield reduction in canola.

Control Tips

Use certified seed that is free of cleavers. All grades of pedigreed seed must be free from cleavers seed. Clean tillage and harvesting equipment before changing fields.

Winter annual cleavers should be controlled in the fall after germination with tillage or a herbicide.

Herbicide options are available in cereal crops, field peas, and herbicide tolerant canola varieties. There are no herbicides registered for control of cleavers in conventional canola.

Dandelion

Dandelion can be a problem weed in pastures, alfalfa and reduced tillage fields. Established plants and seedlings can severely interfere with the establishment of legumes.

Biology

Dandelions are perennials, reproducing by seed. Almost stemless, they have deep, fleshy tap-roots. The leaves are in a rosette, 7.5–25 cm (3–10 in.) long, variable in shape, and lobed. The flowers are bright yellow and are produced on a hollow, upright stem that is 30–45 cm (11–18 in.) in height. The seeds are 3 mm (1/8 in.) long and attached to a hairy parachute that floats in the wind.

Scouting Techniques

Take a minimum of 20 weed counts across the field. Check field edges

as weed seeds often blow in from nearby shelterbelts, turf, and undeveloped areas.

Effects on Crop Quality

Dandelion usually has little effect on forage crop quality.

Threshold/Yield Loss

Established dandelion causes yield losses in annual and winter annual crops and perennial forage seed crops. Dandelions can shorten the productive life of perennial forage seed crops. Productivity in pastures and hay crops is also reduced by dandelions.

Control Tips

Because dandelion has a simple taproot, tillage can be effective for control. Tillage must be deep enough to cut the root 10 cm (4 in.) below the crown. Heavy-duty cultivators and deep tillers are most successful. Discers are often ineffective in well-established stands.

Dandelion invasion of alfalfa does not cause thinning of established stands. Stands are thinned by other factors such as winter-kill. Thus, it is important to maintain a vigorous stand through proper fertilization, cutting, and other control measures. Dandelion leaves have fairly good forage quality and their presence in the forage, especially when harvested as silage, does not significantly reduce the feeding value of the crop.

Dandelions are often a problem in over-grazed pastures and turf because the weed thrives in conditions of close cropping or mowing. A good fertility program in forages will encourage crop competition that reduces dandelion problems.

Herbicides are available for control of dandelion seedlings in cereal crops. Established dandelions can be controlled with glyphosate applied pre-seeding or post-harvest, but pre-harvest treatments are the most effective. There are no herbicides registered for control in alfalfa. Rotating the field out of forages may be required on these fields.

Hemp-Nettle

Hemp-nettle is a vigorous competitor for space and nutrients. Widespread in the Prairies, it is difficult to manage once it becomes established.

Biology

An annual, reproducing by seeds, this weed has stems that are square and covered with bristly hairs. The stems are 30–75 cm (12–30 in.) high and are swollen at the nodes. The leaves are opposite, 5–10 cm (2–4 in.) long, coarsely toothed, hairy, and long-stalked. The flowers are clustered in the axils of the upper leaves and are white or

pink, suffused with purple. The seeds can remain dormant for long periods of time, making it hard to manage this weed once it becomes established.

Each flower produces a cluster of 4 seeds. Hemp-nettle germinates best at high temperatures. It thrives in open, wooded areas, cultivated fields, and undeveloped areas.

Scouting Techniques

Take a minimum of 20 weed counts across the field. Check low spots for patches. Scout fields early as the weed is most sensitive to herbicides in early stages.

Effects on Crop Quality

Hemp-nettle seeds are difficult to clean from grain.

Threshold/Yield Loss

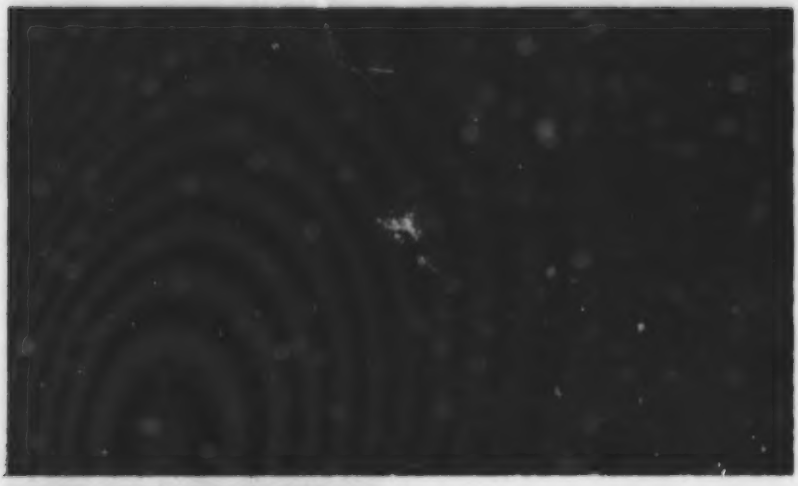
Crops differ widely in their ability to tolerate this weed. Hemp-nettle densities of 150–225 plants per square metre (sq. yd.) can reduce wheat yields by 20–40%. Canola yields can be reduced by up to 25% at weed densities of 130 plants per square metre (sq. yd.). With densities of 400 plants per square metre (sq. yd.), hemp-nettle can reduce yields of oats by 30% and seedling alfalfa by 85%.

Control Tips

Sow clean, certified seed to prevent its accidental spread. Early sown, uniform stands of competitive crops such as wheat, barley and canola are effective at suppressing hemp nettle.

Herbicides are available in cereal crops, canola and peas. Flax and certain special crops are limited in terms of herbicide options.

Lamb's Quarters



A common weed that can cause yield losses in many crops if not controlled early. The oxalic acid produced by this plant can be poisonous to sheep and swine if ingested in large amounts.

Biology

This weed is an annual, reproducing by seeds. The stems are erect, 60–90 cm (2–3 ft.) high, smooth, and longitudinally grooved. They are often red or light green striped. The leaves are alternate, variable in shape, 2.5–8 cm (1–3 in.) long, stalked, coarsely toothed, and covered with white mealy particles, especially on the lower surface. The flowers are small, green, and present in the leaf axils and at the top of the stem.

Although it seems to grow best on disturbed, high-organic soil (e.g., around livestock buildings), it also grows well in cultivated fields. Lamb's quarters produce many long-living seeds (about 72,000 seeds per plant). The seeds germinate both early and late in the season. The greatest flush in germination occurs at the beginning of the growing season.

Scouting Techniques

Take a minimum of 20 weed counts across the field. You may find this weed more often in mixed farming operations than in other situations.

Effects on Crop Quality

The seeds can be a contaminant in grass seed. The green matter can contaminate cereal seed.

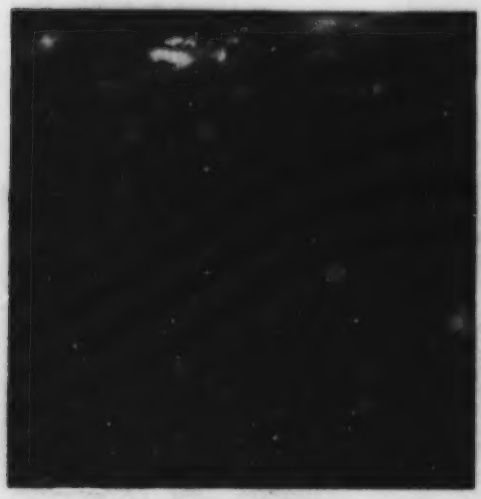
Threshold/Yield Loss

Densities of more than 200 lamb's quarters per square metre (sq. yd.) can reduce barley yields by 20–25%. Because wheat is less competitive than barley, you can expect even greater yield reductions in wheat at this weed density.

Control Tips

Lamb's quarters can be controlled by herbicides in most crops. There are no post-emergent products for control of this weed in conventional (non-herbicide tolerant) canola, but pre-emergent herbicide options exist (eg. trifluralin).

Perennial Sow thistle



Perennial sow thistle is common in cultivated areas, ditches, pastures, and undeveloped areas.

Biology

This weed is a tall, creeping perennial that reproduces by seed and horizontal, underground roots. The roots penetrate to a depth of 1.5–3 m (5–10 ft.). The stems are erect, hollow, 0.5–1.2 m (2–4 ft.) high, smooth, stout, and branch at the top. They produce a milky sap. The leaves are alternate, have slightly-toothed margins, and are 15–30 cm (6–12 in.) long. The lower leaves have deeply-cut, backwards-pointed, side lobes. The upper leaves are slightly-toothed and smaller.

The flowers are bright yellow, dandelion-like, and 1.3–5 cm (1–2 in.) across. The seeds are brown, ridged, and wrinkled with a tuft of fine white

hairs. Carried by the wind, the seed can establish itself in cultivated fields, roadsides, on the margins of sloughs, and along shelterbelts. It prefers moist, fertile soils.

Scouting Techniques

Take a minimum of 20 weed counts across the field. Perennial sow thistle typically occurs in patches.

Effects on Crop Quality

Perennial sow thistle can slow harvest. Green matter in grain can increase drying costs and dockage.

Threshold/Yield Loss

Light infestations of perennial sow thistle cause yield losses in field crops, horticultural crops and forages.

Control Tips

A multi-year integrated control plan must be used. This could include tillage, patch mowing, in-crop herbicides, pre-harvest and post-harvest herbicides, and crop rotation. Avoid lentils and peas. The keys to control are recognizing the problem and being persistent.

Mechanical control may increase or decrease infestations. Tillage may increase infestations by moving these weeds to new areas of the field or by breaking dormancy of underground buds, resulting in new shoot growth. Tillage during cool, wet conditions provides little control.

Pre-harvest applications of glyphosate and products that contain clopyralid or glufosinate will control perennial sow thistle.

Redroot Pigweed

This weed can be difficult to control in non-competitive crops like flax. It can also act as a host for tarnished plant bug which, in turn, can infest many field crops.

Biology

Redroot pigweed grows in cultivated fields, pastures, roadside ditches, and undeveloped areas. It is a common annual weed, producing many seeds that remain viable for up to 5 years. It has a long, fleshy, reddish to pink taproot. The stems are erect, light green, stout, branched, 60–90 cm (1–3 ft.) high, rough, and angular. The leaves are alternate, stalked, dull green, ovate, rough, and 8–10 cm (3–4 in.) long. The flowers are numerous, small, green, crowded into dense finger-like spikes in axils of the leaves, and in a large terminal spike or panicle.

Redroot pigweed requires high temperatures for germination (optimally,

in the 20–30° C or 70–85° F range) and will continue to germinate throughout the summer if there is adequate soil moisture. It will grow almost anywhere and in any crop but is most abundant on rich soils, thriving at higher temperatures.

Scouting Techniques

Take a minimum of 20 weed counts across the field. Scout frequently because under hot conditions, redroot pigweed can advance through it's growth stages quickly, potentially escaping the window for herbicide application.

Effects on Crop Quality

This weed, because it is an alternate host for many crop insect pests, can indirectly affect the development of field crops.

Threshold/Yield Loss

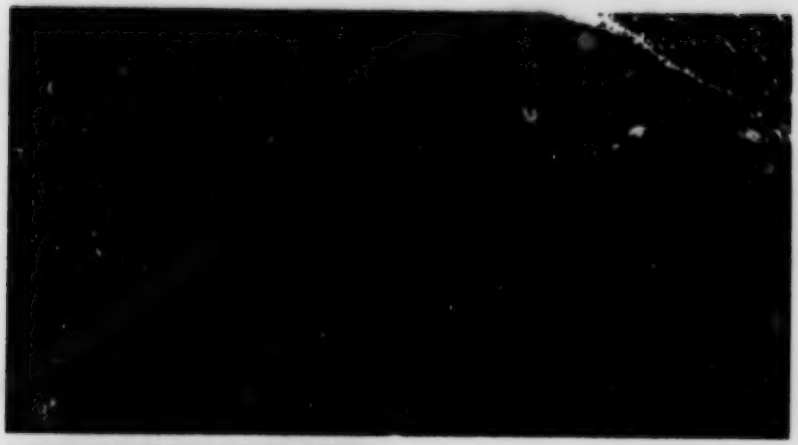
Redroot pigweed causes yield losses in most crops, particularly under hot conditions.

Control Tips

Crops established before soils warm and hot weather sets in are very competitive with redroot pigweed.

Herbicides are available in most crops for control of redroot pigweed. Watch growth stages carefully under hot conditions because the weed can quickly advance beyond the recommended stages for herbicide application.

Round-leaved Mallow



Round-leaved mallow is a prolific weed in gardens, farmyards, shelterbelts, and undeveloped areas. In cultivated crops, it can be very competitive and spreads quickly by seed.

Biology

This weed is considered to be an annual to a short-lived perennial, reproducing by seed. The stems are usually prostrate and up to 1 metre (1 yd.) long. The leaves are alternate, one per node and roughly circular in outline, 2–5 cm (1–2 in.) in diameter, have wavy margins, and are shallowly 5–7 lobed and long stalked. The flowers are inconspicuous, pale-purple to white, 5 mm (1/4 in.) across, and are present in groups of 1–3 at the bases of the leaf stalks. The seeds are arranged in a ring, separating like slices of an orange.

The hard seed coat enables this weed to remain dormant in the soil for up to 100 years. Seeds germinate in moist soils late in the spring, optimally at temperatures of 15–20° C (60–68° F), growing throughout the summer.

Scouting Techniques

Take a minimum of 20 weed counts across the field. Check field edges, old farmyards or areas where manure has been spread, for patches of this weed.

Effects on Crop Quality

Remaining green well into the fall, mats of weed debris can clog farm equipment. Green matter and seeds can result in dockage.

Threshold/Yield Loss

This weed can cause significant yield loss in poorly competitive crops such as flax. Twenty mallow plants per square metre (sq. yd.) can reduce flax yields by 10–30%. In wheat, yield losses are generally lower and much more variable. One report stated that densities of up to 237 plants per square metre (sq. yd.) caused wheat yield losses of up to 15%.

Control Tips

Tillage can be used to control the short-lived perennial form of the weed in the fall and early spring. There is usually no benefit to tilling summer annual plants in the fall, as they have already set seed and won't survive the winter.

Competitive crops such as cereals and canola tend to keep this weed in check, especially when seeded heavy. Avoid crops like flax that are uncompetitive and don't have herbicides available for control of round-leaved mallow.

Herbicide options for control of round-leaved mallow are limited and not highly effective in most crops.

Shepherd's Purse

A common weed that is easy to control in some crops but difficult to control in canola and in reduced tillage systems.

Biology

This weed is an annual or a winter annual. It reproduces by seed. The stems are single or branching at the base, erect, 15–50 cm (6–20 in.) high, and covered with grey hairs. The basal leaves are deeply lobed and form a

rosette on the ground. The stem leaves are alternate and clasp the stem. The flowers are small with white petals. The pods are flattened, triangular, and notched at the top.

Each pod produces about 20 seeds. Shepherd's-purse produces up to 38,500 seeds per plant. Thriving in fields, gardens, and undeveloped areas throughout the Prairies, it flowers from early spring until late fall.

Scouting Techniques

Take a minimum of 20 weed counts across the field.

Effects on Crop Quality

This weed has little effect on crop quality.

Threshold/Yield Loss

Although this weed can cause yield reductions, threshold data are not available.

Control Tips

Winter annual plants that germinate in the fall or the late summer are hard to control the next spring. Therefore, it is best to control them by cultivation or a herbicide treatment in the fall before freeze-up.

Herbicides are available for control of this weed in most crops. With the exception of the herbicide tolerant canola varieties, there are no post-emergent controls for this weed in canola.

Smartweed

At high densities, smartweed can cause significant yield reductions in cereal and oilseed crops.

Biology

This weed is an annual that reproduces by seed. Stems are branched, up to 80 cm (30 in.) tall and hairless. The leaves are stalked and tapering towards both ends. They are widest near the middle, up to 8 cm (6 in.) long and 1.5 cm (1/2 in.) wide. The lower leaves are hairless. Some of the leaves may have a reddish "thumb print". The base of the leaf stalk has a papery sheath surrounding the stem. The sheath is hairless. The flowers are grouped into dense clusters at the ends of the stems and on short stalks

arising from the bases of the upper leaves. The flowers are usually green.

Smartweed produces about 3,000 seeds per plant. It prefers to grow in moist soil conditions and is most common near ponds, dug-outs, and sloughs, especially in the parkland regions.

Scouting Techniques

Take a minimum of 20 weed counts across the field. Check any low spots for patches of this weed because it prefers moist conditions. Annual smartweed is often confused with perennial smartweed, which also occurs in wet spots.

Effects on Crop Quality

Large plants may take a long time to dry in the swath and delay harvesting. Smartweed seed is difficult to clean out of flax.

Threshold/Yield Loss

Smartweed can reduce wheat yields by 30–35% when weed densities are greater than 150–200 plants per square metre (sq. yd.). If the weed emerges 7–14 days after the crop, yield reductions are usually not significant.

Densities of 15–20 plants per square metre (sq. yd.) in canola will reduce yields by 4–5%. If densities reach 100–200 plants per square metre (sq. yd.), yields may be reduced by 25–50%.

Control Tips

Consider growing crops like cereals, canola, and peas on fields with serious smartweed infestations as they offer stronger competition and more effective herbicide options than flax, lentils and other special crops.

Stinkweed

Although stinkweed can compete with crops for moisture and nutrients, a well-fertilized crop that has a head start over stinkweed will compete well. Winter annuals can be difficult to control in the spring.

Biology

This weed is an annual or a winter annual. It reproduces by seed. The plant has an unpleasant odour, particularly when the leaves are crushed. The stems are smooth, erect, 5–60 cm (2–24 in.) high, and often branched. The lower leaves can be in the form of

a rosette. In erect plants, the leaves are alternate and without hairs. The upper leaves clasp the stem. The flowers are small, stalked, and have white petals.

Stinkweed can produce up to 15,000 seeds per plant. The seeds can live for up to 6 years in the tillage zone. Seeds that are buried deeper than the tillage zone can live for up to 20 years and germinate when they come close to the surface. Seed dormancy is enhanced by a thick seed coat. The emergence of summer annuals occurs mainly in the early spring. The seeds of winter annuals germinate in late summer. The seedlings overwinter and continue to grow in the spring.

Scouting Techniques

Take a minimum of 20 weed counts across the field. This weed is usually randomly spread across a field.

Effects on Crop Quality

If eaten by livestock, it can produce an off flavour in both the meat and milk.

Threshold/Yield Loss

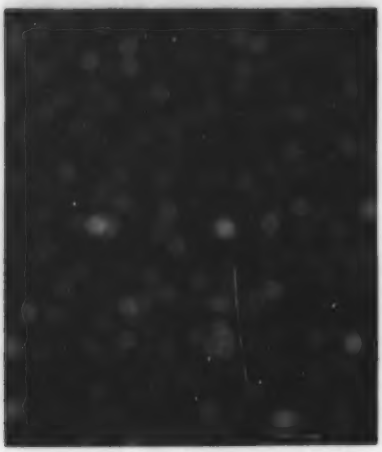
Overwintering stinkweed grows quickly in the spring and can deplete moisture quickly, especially in drier areas. Stinkweed densities as high as 750 plants per metre square (sq. yd.) can reduce wheat yields by 20%.

Control Tips

Winter annual stinkweed plants that germinate in the fall or late summer are hard to kill the next spring. Because winter annuals compete early in the year and set seed before in-crop herbicides are applied, stinkweed should be controlled with tillage or herbicides in the fall before freeze-up.

Herbicide options are available in most crops for control of summer annual stinkweed plants.

Stork's Bill



Low, dense stands of this competitive weed can cause yield reductions and the seed is very difficult to clean out of small seeded crops.

Biology

Stork's bill is an annual, winter annual or biennial. It is usually a low prostrate plant, consisting of a basal rosette and flowering stalks. The stalks are erect, about 40 cm (16 in.) high, and originate in the axils of the leaves. The leaves are divided into fine leaflets, similar to those of a carrot. The flowers are about 1 cm (1/2 in.) across, pink or purplish, and borne in clusters of 2–12 on long flower stalks. The sepals of the flowers are awn-tipped and hairy.

The flower column is 2.5–4 cm (1–1 1/2 in.) long and resembles a stork's bill. At maturity, the developing seed splits into 5 segments, each with a

long, spirally-twisted tail that carries a seed at its base.

The seeds survive for 1–3 years in the soil. When the soil is disturbed, there are flushes of germination. Developing plants prefer cool conditions and tolerate shade well.

Scouting Techniques

Take a minimum of 20 weed counts across the field. Check low spots for patches.

Scout fields early because stork's bill quickly grows past the recommended stages for herbicide application. Note that the first true leaves are very close to the ground and hard to see.

Effects on Crop Quality

Seed may be difficult to clean from small seeded crops like alfalfa.

Threshold/Yield Loss

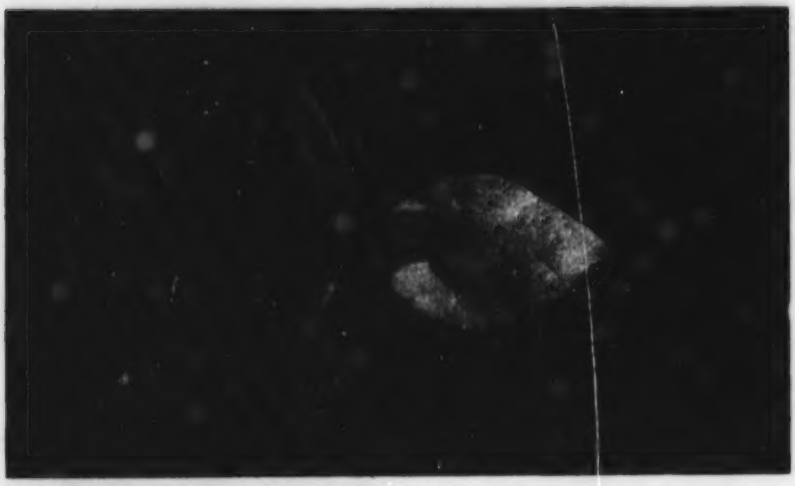
Storks-bill is drought tolerant. During dry seasons, it can seriously reduce crop yields. Densities above 20 plants per square metre (sq. yd.) can cause up to 20% yield reductions in field peas. It is considered to be a serious competitor in dry beans, field peas, and potatoes.

Control Tips

Winter annual stork's bill plants compete and set seed early in the spring and should be controlled the previous fall with tillage after the majority of plants have germinated.

Stork's bill should be treated as early as possible with herbicides. The weed quickly advances through it's growth stages, escaping the window for herbicide application. There are very few herbicides registered for the control of stork's bill.

Wild Buckwheat



Wild buckwheat can cause yield reductions, but is particularly troublesome because of its climbing nature which creates harvesting problems.

Biology

This is an annual weed that reproduces by seed. The stems are slightly angular, 30–90 cm (1–3 ft.) long, trailing on the ground or twining on other plants, and freely branching at the base. The leaves are heart-shaped,

pointed, 13–75 mm (1/2–2 in.) long, alternate, and smooth. The flowers are greenish-white, small, and borne in the leaf axils or at the tip of branches. There are no petals but there are 5 sepals.

Wild buckwheat produces about 1,200 seeds per plant. It thrives under most soil conditions in cultivated fields, cereals, and undeveloped areas.

Scouting Techniques

Take a minimum of 20 weed counts across the field. Check low spots for patches. Scout fields early because this weed is most sensitive to herbicides in its early stages.

Effects on Crop Quality

Wild buckwheat can cause crop lodging and makes swathing and combining difficult.

Threshold/Yield Loss

With 5 plants per square metre (sq. yd.), yield losses of 12% in wheat can occur. With 30 plants per square metre (sq. yd.), yield losses can jump to 22%.

Yield losses of up to 10–20% have been reported in flax with weed densities of 5–15 plants per square metre (sq. yd.). Note that yield losses caused by this weed can be highly variable, depending on whether the weed emerges before, with, or after the crop.

Control Tips

Most crops have herbicide options for control of wild buckwheat. Early application is critical with most herbicides.

Wild Mustard

Wild mustard can cause yield loss and is a serious contaminant of canola seed. If more than 5% wild mustard is present in a canola sample, the canola is graded 'sample reject'.

Biology

The branched stem is erect, about 1 m (3 ft.) tall, and has short, stiff hairs, especially on the lower part of the stem. The leaves are alternate and coarsely-toothed. Like canola, the flowers are bright yellow. Wild mustard has strong, downward-pointing hairs and is a much hairier plant than canola. Also, in canola, the upper leaves clasp the stem whereas, in wild mustard, the upper leaves have stalks.

As wild mustard matures, there is a purple colouring down the stem and close to where the leaf stems attach to

the main stem. Wild mustard produces 2,000–3,500 seeds per plant. The seeds are brown to black and produce a gelatinous coating after soaking in water for a few minutes. Dry conditions early in the season tend to keep populations of wild mustard low.

Scouting Techniques

Take a minimum of 20 weed counts across the field. Wild mustard seedlings look very similar to Polish canola. Take plants confirmed to be Polish canola and wild mustard and compare them for subtle differences. Look between the crop rows when trying to identify wild mustard in Polish canola.

Effects on Crop Quality

Wild mustard seed is similar in size and shape to canola seed. It is impossible to separate by conventional methods. Densities as low as 20 plants per square metre (sq. yd.) in canola may result in wild mustard accounting for up to 5% of the harvested seed, the maximum tolerance of wild mustard in any grade of canola.

Threshold/Yield Loss

Wild mustard is highly competitive with wheat. Left unchecked, 10 wild mustard plants per 0.1 square metres (sq. ft.) can reduce wheat yields by 10–20 bushels per acre or 35%.

As few as 10 mustard plants per square metre (sq. yd.) can reduce flax yields by 25–50%. The threshold for wild mustard in canola is 3 plants per square metre (sq. yd.). With 33 plants per square metre (sq. yd.) in field peas, yields can be reduced by up to 65%, depending on seeding rates and row spacing. With 4–16 wild mustard plants per foot of row in sunflower, yields can be reduced by 25–30%.

Control Tips

Wild mustard flourishes under cool, moist conditions. Pay attention to weed staging under these conditions as it grows quickly and can escape the window for herbicide application. Herbicide options are available in most crops.